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UTILITY REISSUE PATENT
APPLICATION TRANSMITTAL LETTER

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Sir:

Enclosed for filing is the utility reissue patent application of U.S. Patent No. 5,790,272 by Hiroshi GOTO and Satoshi DEISHI for MULTI-TONE IMAGE PROCESSING METHOD AND APPARATUS .

Also enclosed are:

[X] 22 sheet(s) of [X] formal [ ] informal drawing(s);

[X] a claim for foreign priority under 35 U.S.C. §§ 119 and/or 365 was made to 5-259691 filed in JAPAN on 18 October 1993 in the parent application.

[ ] a certified copy of the priority document;

[ ] a Constructive Petition for Extensions of Time;

[ ] ______ statement(s) claiming small entity status;

[ ] an Assignment document;

[X] an Information Disclosure Statement; and

[X] Other: Consent of the Assignee; Offer to Surrender U.S. Patent No. 5,790,272 .

[X] The declaration of the inventors under 37 C.F.R. §1.175 is enclosed.

[ ] Please amend the specification by inserting before the first line the sentence --This application claims priority under 35 U.S.C. §§119 and/or 365 to _ filed in _ on _; the entire content of which is hereby incorporated by reference.--

The filing fee has been calculated as follows [ ] and in accordance with the enclosed preliminary amendment:

CLAIMS					
	NO. OF CLAIMS		EXTRA CLAIMS	RATE	FEE
Basic Application Fee					$760.00
Total Claims	16	MINUS 20 =	0	x $18.00	0
Independent Claims	5	MINUS 3 =	2	x $78.00	156.00
If multiple dependent claims are presented, add $260.00					
Total Application Fee					916.00
If verified Statement claiming small entity status is enclosed, subtract 50% of Total Application Fee					
Add Assignment Recording Fee of $40.00 if Assignment document is enclosed					
TOTAL APPLICATION FEE DUE					916.00

[X] A check in the amount of $ 916.00 is enclosed for the fee due.

[ ] Charge $ ________ to Deposit Account No. 02-4800 for the fee due.

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The Commissioner is hereby authorized to charge any appropriate fees under 37 C.F.R. §§ 1.16, 1.17 and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800. This paper is submitted in triplicate.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

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MULTI-TONE IMAGE PROCESSING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a multi-tone image processing method and apparatus for use in, for example, electrophotographic digital copying apparatus and printers.

2. Description of the Related Art

Various recording methods have been proposed for conventional digital copying apparatus and printers, such as a density pattern method, a dither pattern method and the like for recording multi-tone images.

The density pattern method binarizes original image data of a single picture element by review of a plurality of threshold values associated with a plurality of recording dots, so as to reproduce a plurality of tone levels by a plurality of mutually dissimilar dot patterns. The dither pattern method binarizes original image data of a single picture element by review of one of a plurality of threshold values associated with a plurality of recording dots, so as to reproduce a single picture element of the original image by a single recording dot. A density-dither pattern method combining both the density pattern method and the dither pattern method are also known.

The matrices of threshold values used in the aforesaid methods can be classified as Fattening types wherein dots are concentrated in the center of the matrix in halftone levels, and Bayer types wherein dots are dispersed throughout the entire matrix in halftone levels. When a Bayer type threshold value matrix is used, there is a tendency to have a high degree of gamma recording characteristics. On the other hand, when a Fattening type threshold value matrix is used, resolution is reduced when the matrix size is increased to increase the number of tone levels, and the number of tone levels is diminished when the matrix size is reduced to improve resolution.

An improved halftone method (hereinafter referred to as "IH method") has been provided as a recording method that reconciles both tonality and resolution, wherein a transformed Fattening type threshold value matrix is used, and the sizes of the dots are altered by pulse width modulation, as shown in FIG. 1 (refer to *Electrophotography*, The Society of Electrophotography of Japan, Vol. 25, No. 1, 1986; pp. 31–44). When the aforesaid IH method is used, however, the output characteristics unavoidably include a high degree of gamma characteristics. Thus, only the necessary patterns must be extracted to equalize the steps of density variation so as to obtain linear output. In such an instance, the actual number of reproducible tone levels is less than the theoretical value.

In the previously described methods, it is difficult to achieve adequate compatibility between tonality and resolution. This difficulty is due to the precondition that the frequency of recordings within the matrix range, i.e., the total recording time, must be invariably increased to improve the output density.

SUMMARY OF THE INVENTION

Accordingly, a main object of the present invention is to provide a multi-tone image processing method and apparatus capable of reconciling tonality and resolution.

Another object of the present invention is to provide a multi-tone image processing method and apparatus ideal for electrophotographic apparatus.

From one perspective of the present invention, mutually dissimilar tone levels can be realized by changing the additive condition of recording energy by means of different recording positions, even when the number of recording operations within a specific range is identical.

For example, when an electrophotographic apparatus irradiates the surface of a photosensitive member via a light spot, and thereafter develops the area irradiated by said light spot via a developer, those areas which have received light energy above a predetermined value are rendered visible. When the number of irradiation by a light spot (i.e., total irradiation time) within a specific range remains constant as the irradiation position is changed in the specific range, there is a change in the additive condition of the optical energy within said specific range. Thus, the area rendered visible within the aforesaid specific range also changes, thereby changing the tone level. Using this principle, two or more tone levels can be realized while the number of irradiation by a light spot remains constant within a specific range.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become apparent from the following description of a preferred embodiment thereof taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an illustration showing multi-tone recordings of a conventional improved halftone method;

FIG. 2 briefly shows the construction of an embodiment of a printer;

FIG. 3 is a perspective view briefly showing the construction of the scanning optical system of the printer in FIG. 2;

FIG. 4 is a block diagram showing the semiconductor laser drive circuit of the scanning optical system in FIG. 3;

FIG. 5 is an illustration showing the address designation timing in the circuit of FIG. 4;

FIG. 6 shows the exposure patterns PSA1–PSA4;

FIG. 7 shows irradiation energy distributions corresponding to the exposure patterns of FIG. 6;

FIG. 8 shows the recording states on the recording paper corresponding to the exposure patterns of FIG. 6;

FIG. 9 shows the optical energy distributions via the movement of the optical beam;

FIGS. 10A–10K show exposure patterns PSB0–PSB128;

FIG. 11 shows exposure patterns PSC1–PSC3;

FIG. 12 shows the optical energy distribution corresponding to the exposure pattern PSC2 of FIG. 11;

FIG. 13 shows the recording state on the recording paper corresponding to exposure pattern PSC2 of FIG. 11.

In the following description, like parts are designated by like reference numbers throughout the several drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 2 briefly shows the construction of an embodiment of printer 1. Printer 1 comprises scanning optical unit 11, photosensitive drum 12, charger 13, developing device 14, and transfer charger 15. Photosensitive drum 12 is rotatable at constant speed in the arrow direction in the drawing; the surface of photosensitive drum 12 is uniformly charged to a predetermined potential by charger 13. Laser beam LB emitted from scanning optical unit 11 irradiates the surface of photosensitive drum 12 so as to form an electrostatic latent image thereon. The electrostatic latent image is devel-

oped by developing device 14, thereby being rendered visible as a toner image. The toner image is transferred onto recording paper PP via transfer charger 15, and fused onto the recording paper PP via a fixing device not shown in the illustration.

FIG. 3 briefly shows the construction of scanning optical unit 11. Semiconductor laser 21 emits laser beam LB in accordance with image information read from the memory of a control section not shown in the drawing. Laser beam LB is collimated by collimator lens 22, and deflected by polygonal mirror 23. Deflected laser beam LB passes through fθ lens 24 and impinges the surface of photosensitive drum 12. The beam scanning of the surface of photosensitive drum 12 is realized via the rotation of polygonal mirror 23. In the aforesaid beam scanning, the light at the starting edge of the laser beam scan line is reflected by mirror 25, and arrives at sensor 26. An output signal from sensor 26 is used as a synchronization signal for beam scanning in the main scan (horizontal or row) direction H. Scanning in the sub-scanning direction (vertical or column), which is perpendicular to the main scan direction, is realized via the rotation of photosensitive drum 12.

Drive circuit 30 of semiconductor laser 21 comprises pattern read only memory (ROM) 31, Z-address counter 32, X-address counter 33, Y-address counter 34, and driver 35, as shown in FIG. 4.

Pattern ROM 31 stores a plurality of exposure patterns of m*n matrices. With respect to the exposure pattern specified by Z-address counter 32, the value of each cell is sequentially specified by X-address counter 33 and Y-address counter 34, and is output as 1-bit data DE.

Z-address counter 32 generates and outputs Z-address Z for image data DG of every single picture element based on the image data DG read out from an image memory not shown in the drawings. Image data DG is, for example, a digital signal expressing a single picture element as 6-bit or 8-bit density information.

X-address counter 33 counts the picture element clock signals SC, and outputs said counter value as X-address X. The picture element clock signal SC is a clock signal having a frequency k-fold (where k is a dividing number) greater than the image clock signal. While a single picture element of image data DG is being input, k discrete picture element clock signals SC are generated. X-address counter 33 repeatedly counts within a predetermined range corresponding to cells arrayed in the horizontal direction (main scan direction) of the exposure pattern. For example, if the exposure pattern size is 4 (vertical) by 16 (horizontal), the count is repeated in the range 0–15, as shown in FIG. 5.

Y-address counter 34 counts the horizontal synchronization signals SH, and outputs the count value as Y-address Y. Y-address counter 34 repeatedly counts in a predetermined range corresponding to cells arrayed in the vertical direction (sub-scanning direction) of the exposure pattern. For example, if the size of exposure pattern PS is 4 (vertical) by 16 (horizontal), the counts is repeated in the range 0–3, as shown in FIG. 5.

Driver 35 controls the ON/OFF switching of semiconductor laser 21 based on data DE read out from pattern ROM 31.

Exposure pattern comprises an m*(m*k) matrix wherein each element DT of a square matrix comprising m discrete elements DT in both horizontal and vertical directions are divided into k segments in the horizontal direction, said matrix specifying the respective segments as cells EM. Each cell EM is given a value of either "0" or "1". When a cell EM

value is "0", semiconductor laser **21** is OFF. When a cell EM value is "1", semiconductor laser **21** is ON. Accordingly, the area on the surface of photosensitive drum **12** corresponding to the ON state of semiconductor laser **21** is subjected to light exposure, thereby reducing the potential of said exposed area, such that toner adheres to the surface of the drum at such exposed areas, with the result that those areas are rendered black on the surface of recording paper PP. Conversely, the areas of the recording paper PP corresponding to the OFF state of semiconductor laser **21** are rendered white. Hereinafter, the cells EM having a value of "0" are designated EMW, and cells having a value of "1" are designated EMB.

The area of an image recorded in black on recording paper PP via a single EMB is not necessarily constant. That is, the area recorded in black on recording paper PP differs depending on whether or not the cell adjacent to a particular EMB is an EMW cell or an EMB cell, and further differs depending on whether or not said adjacent position is to the left or right or top or bottom.

This phenomenon is fully described hereinafter with reference to FIGS. **6**–**9**.

FIG. **6** shows PSA1–PSA4 as examples of exposure patterns. FIG. **7** shows the optical energy states corresponding to exposure patterns PSA1–PSA4 of FIG. **6**. FIG. **8** shows the recording state on recording paper PP corresponding to exposure patterns PSA1–PSA4 of FIG. **6**. FIG. **9** shows the optical energy distributions due to movement in the main scan direction by the laser beam. FIGS. **7** and **8** were derived by simulations. FIG. **8** shows the recording state with binarization using 5.2 erg as the threshold value.

Exposure patterns PSA1–PSA4 are 3*12 matrices wherein discrete elements DT of a square matrix of 3*3 elements are divided into four segments in the main scanning direction. In FIG. **6**, EMW is indicated in white, and EMB is indicated in black.

EMB corresponds to the irradiation of the surface of photosensitive drum **12** by a laser beam emitted from semiconductor laser **21** when said semiconductor laser **21** is in the ON state. A single EMB corresponds to the irradiation, i.e., exposure, of the photosensitive drum per unit time. The total number of EMB is the total exposure time.

The discrete elements of the square matrix correspond to single picture elements of image data DG, and pulse width modulation of semiconductor laser **21** is accomplished to divide discrete elements into four segments. Laser beam LB may be, for example, a round shape having a diameter of about 60 μm with a static state half-intensity width in the main scan direction and sub-scanning direction, such that the energy level is greater in the center portion of said beam and diminishes gradually approaching the outer boundary of said beam. After laser beam LB scans a one-line segment in the main scan direction on the surface of photosensitive drum **12**, the next line is scanned, such that adjacent cells EM in the main scan direction of the exposure pattern are scanned continuously, and adjacent cells EM in the sub-scanning direction are scanned non-continuously, i.e., discretely with spatial intervals.

As a result, when EMB cells are adjacent in the main scan direction, the optical energy of the laser beam is additively increased, such that the maximum optical energy increases, as shown in FIG. **9**. Conversely, when EMB cells are adjacent in the sub-scanning direction, the participating optical energy is small, such that the maximum optical energy is not appreciably greater. That is, even when the number of EMB cells is identical, i.e., the total exposure

time is identical, EMB cells are adjacent and continuous in the main scan direction and the maximum optical energy increases, whereas when the EMB cells are adjacent in the sub-scanning direction, the maximum optical energy is less. Accordingly, even though the total exposure time is identical, electrostatic latent images are formed on the surface of photosensitive drum 12 via different optical energies.

In electrophotographic recording, toner adheres only to areas that have received optical energy which surpasses a particular threshold value in accordance with the sensitivity of the photosensitive drum 12 and magnitude of the developing bias, thereby developing a latent image and forming a black image. Accordingly, when developing electrostatic latent images formed by mutually different optical energies, the areas of the formed images are different. That is, even though the number of individual EMB cells is identical, the areas of the image recorded on the recording paper PP can differ by changing the arrangement positions of the EMB cells. Using this principle, recording of mutually dissimilar tones can be realized due to mutually different EMB cell positions in relation to a plurality of exposure patterns having mutually identical numbers of EMB cells.

In FIG. 6, exposure pattern PSA1 has a total of four EMB cells, and the center element DT is recorded as black. In this instance, the optical energy produces nearly concentric circles, as shown in FIG. 7, and a circular black image FG1 in the center is recorded, as shown in FIG. 8.

In all the exposure patterns PSA2–PSA4 of FIG. 6, the total number of EMB cells is five, and 5/4 elements DT are recorded. The positions of the EMB cells in these patterns are mutually dissimilar. In exposure pattern PSA2, five EMB cells are arranged consecutively in the horizontal direction; in exposure pattern PSA3, a single EMB cell is arranged on the line above the other four EMB cells; in exposure pattern PSA4, two EMB cells are arranged on the line above the other three EMB cells. Thus, as shown in FIG. 7, the optical energy is greatest for exposure pattern PSA2 having five consecutive EMB cells in the horizontal direction, and the optical energy is least for exposure pattern PSA4 having the fewest number of consecutive cells. Therefore, as shown in FIG. 8, image FG2 corresponding to exposure pattern PSA2 is largest, and image FG4 corresponding to exposure pattern PSA4 is smallest. The dot area ratios (%) of images FG1–FG4 of exposure patterns PSA1–PSA4 were 2.6, 8.0, 5.0, and 1.3, respectively. As can be clearly understood from a comparison of images FG1 and FG4, the fewer the number of EMB cells the greater the area of the image recorded on recording paper PP via the position of EMB cells of the exposure pattern.

As previously described, it is possible to increase the number of tone levels by changing the positions of EMB cells while maintaining uniformity of the element dividing number and size of the matrix of the exposure patterns. That is, the number of tone levels can be increased without reducing resolution. Linearized tonal characteristics can be obtained by combining the total number of EM cells and the position of discrete EM cells.

Returning now to FIG. 4, when image data DG are 8-bit data expressing 129 tone levels including all white and all black, 129 individual exposure patterns are stored in pattern ROM 31.

FIGS. 10A–10K show 129 discrete exposure patterns PSB0–PSB128 stored in pattern ROM 31. Exposure patterns PSB0–PSB128 are 4*16 matrices wherein each element DT of a 4*4 dot square matrix is divided into four segments in

the horizontal direction. In the drawing. EMW indicates a white cell, and EMB indicates a black cell.

The aforesaid exposure patterns PSB0–PSB128 express exposure patterns of tones from level "0" to level "128" among the 129 tone levels, and express the Z-addresses 0–128, respectively. These exposure patterns PSB0–PSB128 are selectable so as to obtain linear output characteristics relative to scanning optical unit 11 having the optical characteristics described below.

Resolution: 2400 DPI in main scan direction 600 DPI in sub-scanning direction

Image clock: 8.9 MHz

Laser intensity: 0.23 mW

Static beam diameter (half-intensity): 60 μm in both main and sub-scan directions

In Z-address counter 32, Z-address Z is generated which corresponds to the image data DG value, and which specifies one of the exposure patterns PSB. Cells EM of the specified exposure patterns PSB are sequentially read according to X-address X and Y-address Y specified by X-address counter 33 and Y-address counter 34 and generated as data DE, and the semiconductor laser 21 is switched ON/OFF in accordance with the value of said data DE. Z-address Z, X-address X, and Y-address Y may be combined as necessary, to accomplish pattern ROM 31 address specification via said combined addresses.

According to the construction of the present embodiment, the number of tone levels can be determined by the number of exposure patterns, and the tone levels can be set fractionally.

Furthermore, although the value of each EM cell is binary in the present embodiment as described above, it is to be noted that said values may be ternary or greater. Ternary or greater values allow an increased number of tone levels and improve image quality. Furthermore, the dividing number k may be decreased, and that fraction augmented by multilevel values to maintain the same number of tones, while reducing frequency of the picture element clock signal SC.

FIG. 11 shows ternary exposure patterns PSC1–PSC3. Exposure patterns PSC1–PSC3 are 3*12 matrices are divided into four segments of 3*3 square elements DT in the horizontal direction, and each cell EM is a value of either "0", "1", or "2". In the following description, cells with a value of "0" are designated EMW, cells with a value of "1" are designated EMG, and cells with a value of "2" are designated EMB. In FIG. 11, EMW cells are white, EMG cells are gray, and EMB cells are black. FIGS. 12 and 13 show optical energy states and recording states on recording paper PP corresponding to the exposure patterns PSC2.

Although semiconductor laser 21 is switched ON in correspondence with EMG and EMB, said laser is ON at the rated intensity for EMB and ON at one half the rated intensity for EMG.

Even when the total number of cells EMB and EMG are identical in the aforesaid exposure patterns PSC, the ratio of cells EMB to EMG, and there relative positional arrangements produce different areas of image FG recorded on recording paper PP. Accordingly, the number of tones may be increased to a number greater than the aforesaid exposure patterns PSA.

Although recorded at identical threshold values, the area of image FG in exposure pattern PSC1 is between the aforesaid exposure patterns PSA1 and PSA2, the area in exposure pattern PSC2 is smaller than that of PSC3, and the maximum optical energy in pattern PSC3 is below the threshold value such that the image cannot be recorded. The

dot area ratio (%) of the images FG in exposure patterns PSC1–PSC3 are 5.1, 3.8, and 0.0, respectively.

Although a scanning optical system 11 having a semiconductor laser 21 is used in the previously described embodiment, it is to be understood that an optical system having an LED array, liquid crystal, PLZT or the like may be alternatively used.

A single elements DT of exposure patterns PS correspond on one-to-one basis with a single picture element of image data DG in the present embodiment, but is to be noted that a single exposure pattern PS may correspond to a single picture element of image data DG. Furthermore, a plurality of elements DT of exposure pattern PS may correspond to a single picture element of image data DG, and a single cell EM or a plurality of cells EM may correspond to a single picture element of image data DG.

Although the previously described embodiment has been described in terms of exposure patterns wherein the screen angle is at 0 and recording image is thickened from at single point, this method is obviously applicable to other types of exposure patterns. For example, when applied to fill color printers, use of exposure patterns which set different screen angles for each color may similarly be considered for normal printing.

The present embodiment is further applicable to recording or displaying by methods other than electrophotographic recording methods, such as thermal recording methods or ink jet recording methods.

The embodiment described above provides a multi-tone recording method and apparatus that reconciles tonality and resolution at low cost. Furthermore, the present embodiment increases the freedom of tonal expression, while improving the linearity of tonal characteristics by reconciling tonality and resolution.

Although the present invention has been fully described by way of examples with reference to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as being included therein.

What is claimed is:

1. A multi-tone image processing method comprising:

receiving a plurality of image data wherein each image data represents a tone level;

specifying a pattern from a plurality of patterns stored in a memory in response to each of said image data, each of said plurality of patterns defining a number of recording operations and positions of recording operations within a specific range;

wherein each pattern represents a specific tone level and wherein different tone levels may include a same number of recording operations at different positions within the specific range; and

generating recording data for executing recording operations by reviewing the pattern specified for each image data.

2. A multi-tone image processing method as claimed in claim 1, wherein all of the recording operations are of substantially the same intensity.

3. A multi-tone image processing method as claimed in claim 1, wherein more than one tone level includes the same number of recording operations at different positions.

4. A multi-tone image processing apparatus for receiving multi-tone image data representing a tone level of a multi-tone image and generating recording data based on the multi-tone image data, comprising:

a memory which stores a plurality of patterns corresponding to a plurality of tone levels, respectively, each of said plurality of patterns defining a number of recording operations and positions of recording operations within a specific range, at least two of said plurality of patterns being identical in the number of recording operations but different in the positions of recording operations within said specific range for different tone levels; and

a control unit which specifies one of said plurality of patterns stored in said memory in response to the multi-tone image data and generates recording data by reviewing the specified pattern.

5. A multi-tone image processing apparatus as claimed in claim 4, wherein each of said plurality of patterns is constituted by a matrix in which each element of an m*m square matrix is divided into k segments in a row direction.

6. A multi-tone image processing apparatus as claimed in claim 4, wherein all of the recording operations are of substantially the same intensity.

7. A multi-tone image processing apparatus as claimed in claim 4, wherein each of said plurality of patterns is constituted by an m*n matrix.

8. A multi-tone image processing apparatus as claimed in claim 7, wherein the value of each cell of the m*n matrix is binary.

9. A multi-tone image processing apparatus as claimed in claim 7, wherein the value of each cell of the m*n matrix is ternary or greater.

10. A multi-tone image recording apparatus for recording a multi-tone image based on multi-tone image data representing a tone level of a multi-tone image, comprising:

converting means for converting multi-tone image data into recording data so that at least two tone levels are realized by differentiating positions of recording dots within a specific range while a number of the recording dots remains constant within said specific range; and

a recording system which receives the recording data and produces the recording dots based on the recording data.

11. A multi-tone image recording apparatus as claimed in claim 10, wherein said converting means includes a memory which stores a plurality of patterns corresponding to a plurality of tone levels, respectively, each of said plurality of patterns defining the number of the recording dots and the positions of the recording dots within said specific range.

12. A multi-tone image recording apparatus as claimed in claim 10, wherein said recording system includes a photosensitive member, an optical system which irradiates the photosensitive member by a light spot, and a developing device which develops areas irradiated by the light spot with developer.

13. A multi-tone image processing method as claimed in claim 10, wherein all of the recording dots are of substantially the same intensity.

14. A multi-tone image recording apparatus as claimed in claim 11, wherein each of said plurality of patterns is constituted by an m*n matrix of which each cell corresponds to the recording dot.

15. A multi-tone image recording apparatus as claimed in claim 14, wherein the adjacent recording dots in a row direction of the matrix are produced continuously while the adjacent recording dots in a column direction of the matrix are produced discretely with a spatial interval.

16. A multi-tone image recording apparatus as claimed in claim 15, wherein the recording dots are produced by pulse width modulation in the row direction of the matrix.

17. A multi-tone image recording apparatus comprising:

a photosensitive member which moves in a sub-scanning direction;

a laser optical system which selectively generates a laser beam and scans said photosensitive member with a spot of the laser beam in a main scanning direction substantially perpendicular to said sub-scanning direction;

a developing device which develops areas irradiated by the spot of the laser beam with developer;

a memory which stores a plurality of exposure patterns corresponding to a plurality of tone levels, respectively, each of said plurality of exposure patterns defining a number of irradiation by the spot of the laser beam and the positions of the irradiation within a specific range, at least two of said plurality of exposure patterns being identical in the number of the irradiation but different in the positions of the irradiation within said specific range for realizing different tone levels;

a controller which receives multi-tone image data representing a tone level of a multi-tone image and specifies one of said plurality of exposure patterns in response to the multi-tone image data; and

a driver which drives said laser optical system to control generation of the laser beam by reviewing the exposure pattern specified by said controller.

18. A multi-tone image recording apparatus as claimed in claim 17, wherein each of said plurality of exposure patterns is constituted by an m*n matrix of which each cell corresponds to the irradiation by the spot of the laser beam.

19. A multi-tone image recording apparatus as claimed in claim 17, wherein generation of the laser beam is controlled by pulse width modulation in the main scanning direction.

20. A multi-tone image processing method as claimed in claim 17, wherein all of the irradiations are of substantially the same intensity.

21. A multi-tone image recording apparatus as claimed in claim 17, wherein said laser optical system includes a semiconductor laser.

22. A multi-tone image recording apparatus as claimed in claim 21, wherein said driver switches on and off the semiconductor laser in correspondence with the exposure pattern specified by said controller.

23. A multi-tone image recording apparatus as claimed in claim 22, wherein said driver controls the intensity of the laser beam between three or more levels.

24. (Amended) A multi-tone image processing method comprising:

receiving a plurality of image data wherein each image data represents a tone level;

specifying a pattern from a plurality of patterns, each of said plurality of patterns defining a number of recording operations and positions of recording operations within a specific range, wherein each pattern represents a specific tone level and at least one of the patterns a has larger number of recording operations than another of the patterns that represents a [lighter] darker tone level within the specific range; and

generating recording data for executing recording operations by reviewing the pattern specified for each image data.

[25. A multi-tone image processing method, comprising:

receiving a plurality of image-data, wherein each image data represents a tone level;

specifying a pattern of black and white picture elements from a plurality of patterns, each of said plurality of patterns defining a number of recording operations all of which have substantially the same intensity and positions of the recording operations within a specific range, wherein each of said patterns represents a specific tone level and wherein at least one of the patterns includes a white picture element in a position that includes a black picture element in another of the patterns representing a lighter tone level; and

generating recording data for executing recording operations by reviewing the pattern specified for each image data.

26. A multi-tone image processing method, comprising:

receiving a plurality of image-data, wherein each image data represents a tone level;

specifying a pattern of black and white picture elements from a plurality of patterns, each of said plurality of patterns defining a number of recording operations and positions of recording operations within a specific range, wherein each of said patterns represents a specific tone level and wherein at least one of the patterns includes a white picture element in a position that includes a black picture element in another of the patterns representing a lighter tone level, wherein the another pattern and the at least one pattern have the same number of recording operations; and

generating recording data for executing recording operations by reviewing the pattern specified for each image data.

27. A multi-tone image processing method as claimed in claim 26, wherein all of the recording operations are of substantially the same intensity.

28. A multi-tone image processing method comprising:

receiving a plurality of image data wherein each image data represents a tone level;

specifying a pattern of black and white picture elements from a plurality of patterns, each of said plurality of patterns defining a number of recording operations and positions of the recording operations within a specific range, wherein each of said patterns represents a specific tone level and wherein at least one of the patterns includes a white picture element in a position that includes a black picture element in another of the patterns representing a lighter tone level; and

generating recording data for executing recording operations by reviewing the pattern specified for each image data, wherein said recording operations are executed by a photo emitter which emits a beam having a characteristic in which an energy level is greater in a center portion of said beam than in a remaining portion of said beam.]

* * * * *

29. A multi-tone image processing apparatus for converting multi-tone image data representing a tone level of a multi-tone image to binary image data, said apparatus comprising:

a memory which stores a plurality of patterns representing a plurality of tone levels, respectively, each of said plurality of patterns having effective cells and non-effective cells and defining a number of effective cells and positions of effective cells within a specific range, wherein at least one of the patterns has a larger number of effective cells than another of the patterns that represents a darker tone level within the specific range; and

a converter which specifies one of said plurality of patterns stored in said memory according to the tone level of the multi-tone image data to be converted and converts the multi-tone image data to the binary image data based on the specified pattern.

30. A multi-tone image processing apparatus as claimed in claim 29, wherein each of said plurality of patterns is constituted by a matrix in which each element of an m*m square matrix is divided into k cells in a row directions.

31. A multi-tone image recording apparatus comprising:

a memory which stores a plurality of patterns representing a plurality of tone levels, respectively, each of said plurality of patterns having effective cells and non-effective cells and defining a number of effective cells and positions of effective cells within a specific range, wherein at least one of the patterns has a larger number of effective cells than another of the patterns that represents a darker tone level within the specific range;

a converter which specifies one of said plurality of patterns stored in said memory according to the tone level of the multi-tone image data to be converted and

converts the multi-tone image data to the binary image data based on the specified pattern; and

a printer which prints the image according to the binary image data converted by said converter.

32. A multi-tone image recording apparatus as claimed in claim 31, wherein said converter includes an X-address counter, a Y-address counter and a Z-address counter, said Z-address counter specifying one of said patterns in the memory, and the X-address counter and the Y-address counter specifying one of said cells of the specified pattern according to horizontal and vertical printing operations of said printer.

33. A multi-tone image recording apparatus as claimed in claim 31, wherein said printer includes a light source which emits a light beam, a driver which drives said light source based on the binary image data, an image carrier which moves in a vertical direction, and a deflector which deflects said light beam in a horizontal direction and scans said image carrier to form an image on said image carrier.

34. A multi-tone image recording apparatus as claimed in claim 33, wherein said converter includes an X-address counter, a Y-address counter and a Z-address counter, said Z-address counter specifying one of said patterns in the memory, and the X-address counter and the Y-address counter specifying one of said cells of the specified pattern according to horizontal and vertical scanning operations of said printer.

35. A multi-tone image recording apparatus for recording an image based on multi-tone image data representing tone levels on an image, said recording apparatus comprising:

a converter which converts multi-tone image data into recording data so that at least two tone levels are realized by differentiating positions of recording dots within a specific range while a lighter tone level has a larger number of recording dots than a darker tone level within the specific range; and

a printer which receives the recording data from said converter and records the recording dots based on the recording data.

36. A multi-tone image recording apparatus as claimed in claim 35, wherein said printer includes a light source which emits a light beam, a driver which drives said light source based on the recording data, an image carrier which moves in a vertical direction, and a deflector which deflects said light beam in a horizontal direction and scans said image carrier to form an image on said image carrier.

SPECIFICATION

1. TITLE OF THE INVENTION

GRADATION RECORDING METHOD

2. CLAIMS

A gradation recording method using a density pattern method in which one pixel is divided into a number, N×M, of matrix elements and the number of matrix elements colored with ink is successively increased to thereby increase the recording density level, characterized in that recording of different recording density levels is performed by using density patterns having the same number of colored matrix elements but having different matrix element arrangements.

3. DETAILED DESCRIPTION OF THE INVENTION

[Technical Field of the Invention]

The present invention relates to a gradation recording method having an excellent gradation characteristic.

[Technical Background of the Invention and Its Problem]

In recent years, opportunities to handle characters, figures and the like have been increasing with development of information-related industries, and there are occasions when copying must be performed on recording paper with a printer.

As the method of performing printing on recording paper, a

thermal recording method is widely used which has many advantages such that noise is not produced and that the apparatus size can be reduced.

As the thermal recording method, in a thermal transfer method in which a thermal head is heated to melt ink on ink film and the melted ink is transferred onto recording paper and in other various methods, a binary recording method based on whether ink is transferred onto recording paper or not, namely, "0" and "1" is frequently used.

The binary recording method can express only the next gradation at the minimum by itself. Therefore, in order to maintain a sufficient gradation characteristic, a gradation recording method called a density pattern method which is a kind of area gradation is used in most cases.

The density pattern method is a recording method in which one pixel is brought into correspondence with a matrix consisting of several elements and by changing the filled matrix element by, for example, transferring ink in accordance with the shade of the pixel, that is, by changing the colored area of the ink portion within one pixel, expression with a sufficient gradation characteristic is enabled.

In the density pattern method, even if the number of colored matrix elements or areas is the same, the gradation characteristic varies according to the coloring pattern (dot pattern). A centralized pattern, for example a halftone-dot-type pattern has

a gradation characteristic close to a line with respect to the number of colored matrix elements (coinciding with the number of gradation levels), whereas a distributed pattern, for example a Bayer-type pattern has a gradation characteristic more nonlinear than that of the centralized pattern and its gradation expressing capability is lower.

This phenomenon is explained as follows:

Part of the light intruding into the recording paper is absorbed by recorded dots around the recorded dots. Consequently, the gradation expressing capability is apt to be nonlinear when the boundary line between the recording portion and the non-recording portion is long like the distributed pattern.

When one pixel is divided into a number, $N \times M$, of matrix elements, a number, $N \times M$, of gradations are obtained, and in principle, by increasing the number of matrix elements, the number of gradations can be increased accordingly. However, since resolution decreases unless the area of the matrix elements is decreased, the number of gradations is limited in actuality. Therefore, generally, recording of sixteen gradations is frequently performed by using a 4×4 matrix.

For example, FIGs. 3 and 4 show Bayer-type dot patterns and halftone-dot-type dot patterns in the density pattern method using a 4×4 matrix described in the May 7, 1984 issue of Nikkei Electronics, pp. 171-188. The number below each dot pattern represents a gradation level.

When the binary recording method is used, although the coloring pattern (dot pattern) of the Bayer type or the halftone dot type is an advantageous recording method capable of expressing each pixel with a considerable number of levels of gradations, it has not only a defect that the number of gradations is limited to a number N $\times$M which is the number of matrix elements but also the following defect:

FIG. 5 shows gradation characteristic curves of the Bayer type and the halftone dot type shown in FIGs. 3 and 4. Here, the lateral axis represents the gradation level, i.e. the number of filled (colored) elements among a number, 4$\times$4, of matrix elements, whereas the longitudinal axis represents the reflection recording density.

As is apparent from FIG. 5, even when the Bayer type and the halftone dot type have the same gradation level, they are different in recording density. That is, a recording density which cannot be reproduced by the sixteen gradation levels of the halftone dot type can be reproduced by a gradation level of the Bayer type and conversely, a recording density which cannot be reproduced by the sixteen gradation levels of the Bayer type can be reproduced by a gradation level of the halftone dot type.

Thus, the conventional gradation recording method has a defect that according to the actually used predetermined density pattern such as the Bayer type or the halftone dot type, reproduction (recording) can be performed with a relatively excellent gradation characteristic in a recording density region but recording is

performed with an unintended gradation in a predetermined recording density region to decrease reproducibility.

[Object of the Invention]

The present invention is made in view of the above-described problem, and an object thereof is to provide a gradation recording method capable of realizing an excellent gradation characteristic by enabling recording with a number of gradations which is greater than the number of gradations limited by the number of matrix elements to be used.

[Summary of the Invention]

According to the present invention, in the density pattern method for performing recording with gradation by dividing one pixel into matrix elements, by using a plurality of types of density patterns having different gradation characteristics, a gradient having a greater number of matrix elements is realized to improve the gradation characteristic.

[Preferred Embodiment of the Invention]

Hereinafter, the present invention will be concretely described with reference to the drawings.

FIGs. 1 and 2 are related to an embodiment of the present invention. FIG. 1 shows gradation characteristics according to the embodiment. FIG. 2 shows the gradation characteristics of FIG. 1 as dot patterns for the number of gradation levels.

The embodiment of the present invention will be described in

which gradation recording of one pixel is performed with a 4×4 matrix.

As the density pattern to be used, the halftone-dot-type pattern which is a centralized pattern and the Bayer-type pattern which is a distributed pattern are both used.

In FIG. 1, the solid line represents the gradation characteristic of the halftone-dot-type density pattern, and the broken line represents the gradation characteristic of the Bayer-type density pattern. In the first embodiment, the halftone dot type represented by the solid line is used for the first to tenth and fourteenth to sixteenth gradation levels and both the halftone dot type and the Bayer type are used for the eleventh to thirteenth gradation levels, thereby realizing a recording density state having a pitch finer than that when only one of the two types is used.

That is, at the eleventh gradation level, a Bayer-type recording density a is substantially intermediate between the recording densities at the eleventh gradation level and at the twelfth gradation level of the halftone dot type, and the recording density a cannot be reproduced by a halftone-dot-type density pattern.

Likewise, a recording density b at the twelfth gradation level of the Bayer type and a recording density c at the thirteenth gradation level of the Bayer type are intermediate between the recording densities at the twelfth gradation level and at the thirteenth gradation level of the halftone dot type and between the

recording densities at the thirteenth gradation level and at the fourteenth gradation level of the halftone dot type, respectively, and cannot be reproduced by the halftone-dot-type density pattern.

That is, among the three recording density levels for the eleventh, twelfth and thirteenth gradation levels of the Bayer type and the recording density levels of the halftone dot type, the recording density is higher in the following order:

the eleventh gradation of the halftone dot type < the eleventh gradation of the Bayer type < the twelfth gradation of the halftone dot type < the twelfth gradation of the Bayer type < the thirteenth gradation of the halftone dot type < the thirteenth gradation of the Bayer type < the fourteenth gradation of the halftone dot type. (1)

Therefore, by using the three gradations of the Bayer type in the order of (1) together with the recording densities which can be reproduced by the sixteen gradation levels of the halftone-dot-type density patterns, nineteen density gradations which are more than a number, 4×4, of density gradations can be reproduced with a number, 4×4, of matrix elements.

FIG. 2 shows placement (arrangement) of recorded dots which realizes the recording density of the nineteen gradations in the above-described 4×4 matrix.

In FIG. 2, in patterns (sometimes referred to as density gradation levels. These correspond to gradation levels as described above but do not always coincide with the number of colored

elements (the number of colored dots) unlike the above-described ones) designated by the numerals 0 to 19, Bayer-type density patterns are used for the twelfth, fourteenth and sixteenth patterns, and the numbers of colored matrix elements thereof are equal to those of the twelfth, fourteenth and sixteenth patterns of the halftone dot type, i.e. 11, 12 and 13, respectively.

In the above-described embodiment, halftone-dot-type density patterns are mainly used and Bayer-type patterns are also used as the eleventh, twelfth and thirteenth density gradation levels, thereby realizing the number of gradations which is greater than a number, 4×4(=16), of matrix elements to improve reproducibility. However, the present invention is not limited to the above-described method which also uses the three Bayer-type density patterns but the number of Bayer-type density patterns that are also used may be increased (or decreased in some cases).

While the halftone dot type is mainly used and the Bayer type is used together with the halftone dot type in the above-described embodiment, this may be reversed.

Further, the present invention is not limited to the method which uses both the halftone-dot-type and the Bayer-type density patterns but other density patterns such as the spiral type may be used. Generally, when two different types of density patterns comprising a N×M matrix are used, if the recording densities of the two gradation patterns for given gradation levels are all different where the saturated density level and the zero level are

excepted, a gradation of $N \times M+(N \times M-1)=2(N \times M)-1$ can be reproduced. Moreover, by using three or more different types, the number of gradations can be further increased.

In short, the gradation recording method of the present invention is a method in which when one pixel is formed by a $N \times M$ matrix, gradation recording is performed with density patterns for which density patterns having the same gradation levels but different recording densities are also used, and the number of density patterns can be increased to the number of gradations which is greater than a number $N \times M$.

In other words, the method of the present invention is a method of recording gradation with a number, $N \times M$, of matrix elements in which recording densities with different levels are realized with density patterns having the same number of colored matrix elements but different distributions (patterns).

Consequently, gradation recording of excellent reproducibility is realized. Thus, the present invention effectively uses the defect that even if the number of gradations is the same, the recording density varies according to the distribution of the colored matrix elements.

The present invention is applicable not only to monochrome printers but also to color printers. Moreover, the present invention is applicable to cases other than the case of the binary recording. The present invention is also applicable to a case using the density gradation method.

The present invention is applicable not only to apparatuses of the thermal transfer method but also to apparatuses of the impact dot method.

[Advantageous Effect of the Invention}

As described above, according to the present invention, since the gradation number level can be increased by using different density patterns having the same number of gradations, gradation recording of excellent reproducibility is realized.

4. BRIEF DESCRIPTION OF THE DRAWINGS

FIGs. 1 and 2 are related to the embodiment of the present invention. FIG. 1 is a characteristic view showing that the number of gradations is improved by using the Bayer-type characteristic together with the recording density characteristic for the halftone-dot-type gradation level. FIG. 2 is an arrangement view showing the characteristics of FIG. 1 as the dot patterns for the density gradation levels. FIG. 3 is an arrangement view showing the Bayer-type dot pattern for each gradation level in a case where gradation recording is performed with the 4×4 matrix. FIG. 4 is an arrangement view showing the halftone-dot-type dot pattern for each gradation level in a case where gradation recording is performed with the 4×4 matrix. FIG. 5 is a characteristic view showing the relationship between the gradation level and the recording density in a case where the dot patterns shown in FIGs. 3 and 4 are used.

ABSTRACT

A multi-tone image processing method and apparatus in which mutually dissimilar tone levels are realized by changing the additive condition of recording energy by means of different recording positions, even when the number of recording operations within a specific range is identical. For example, in an electrophotographic apparatus, when the number of irradiation by a light spot within a specific range remains constant as the irradiation position is changed in the specific range, there is a change in the additive condition of the optical energy within said specific range. Thus, the area rendered visible within the aforesaid specific range also changes, thereby changing the tone level.

Fig. 1

(Prior Art)

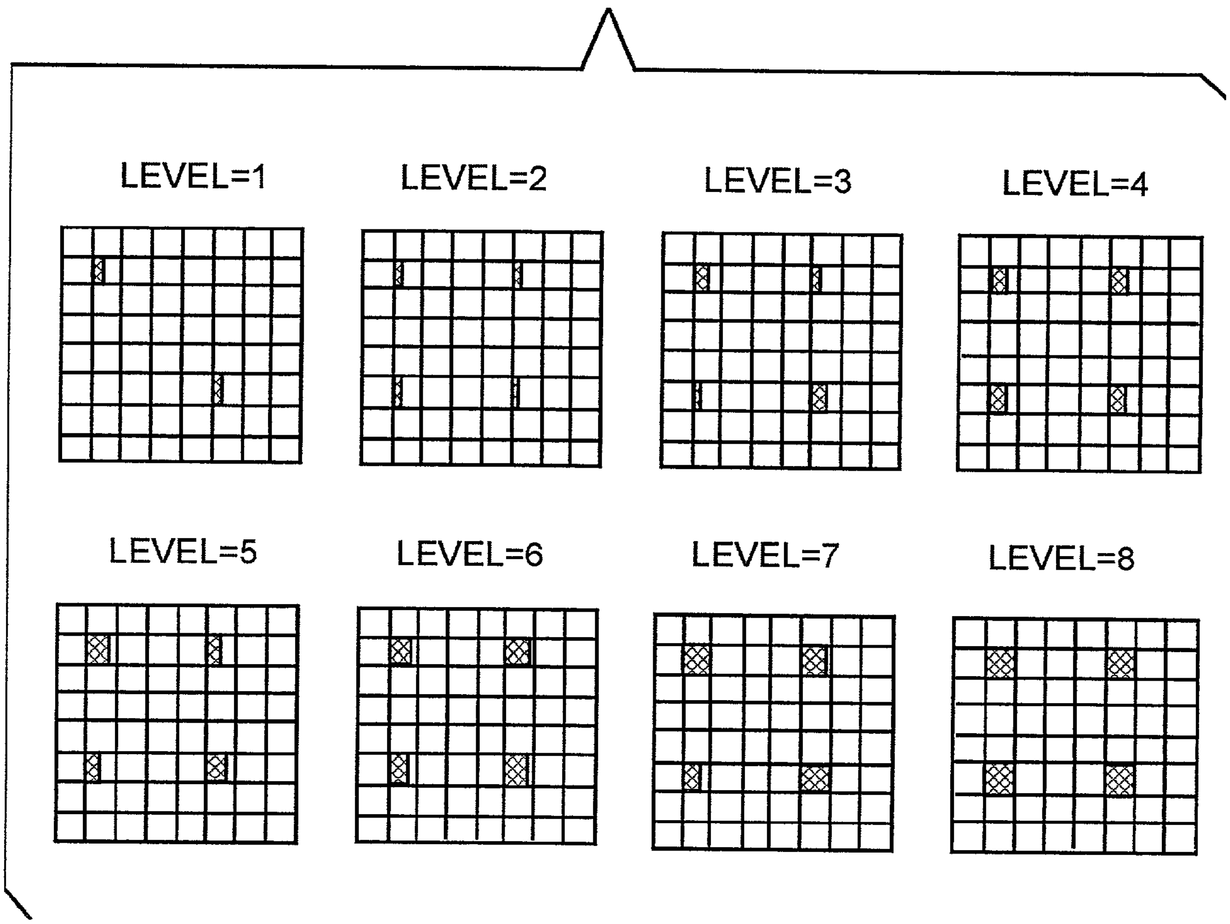


Fig. 2

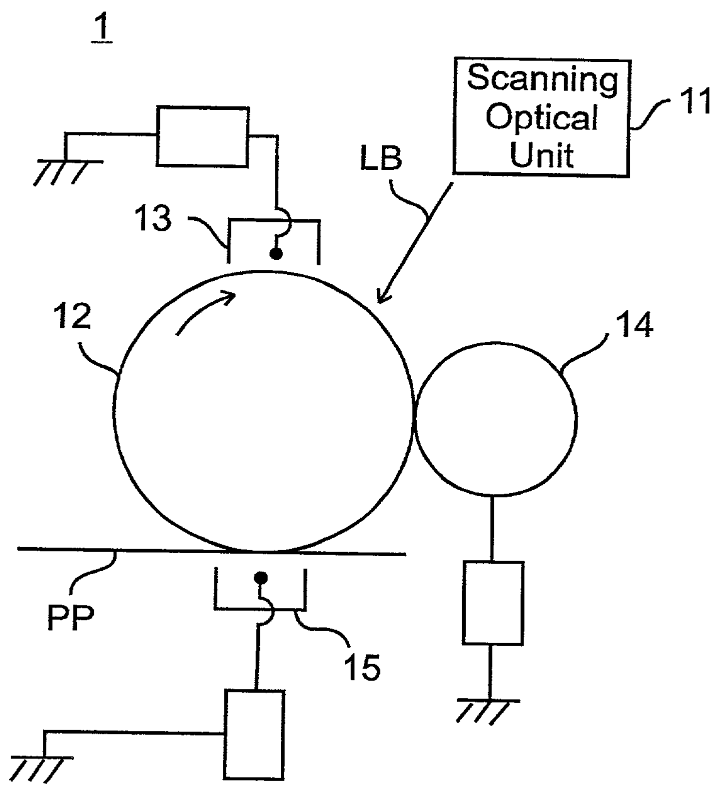


Fig. 3

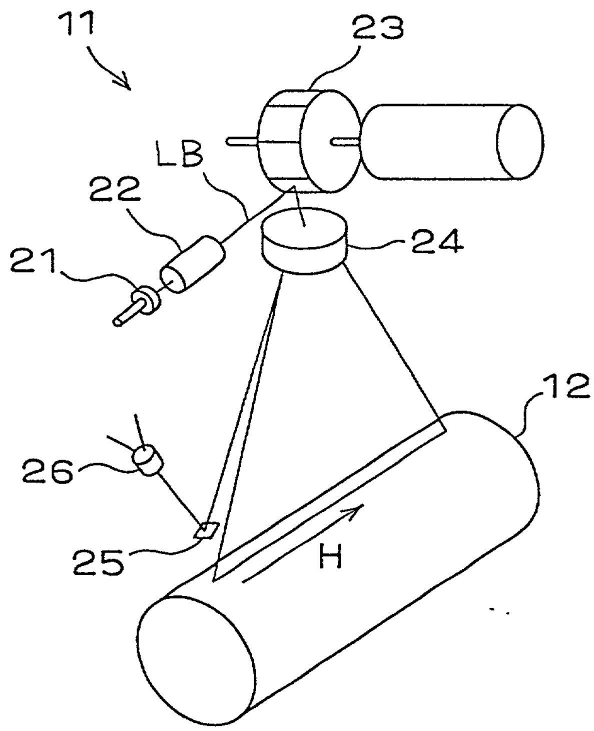


Fig. 4

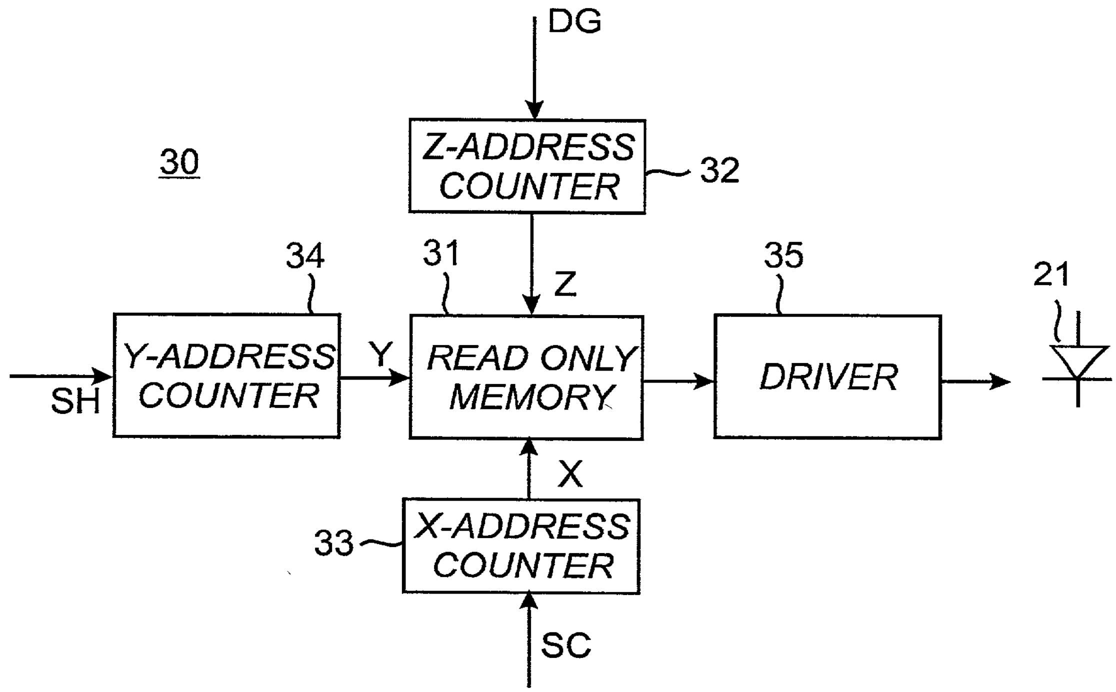

DG
30
Z-ADDRESS COUNTER
32
34
31
Z
35
21
Y-ADDRESS COUNTER
Y
READ ONLY MEMORY
DRIVER
SH
X
33
X-ADDRESS COUNTER
SC

Fig. 5

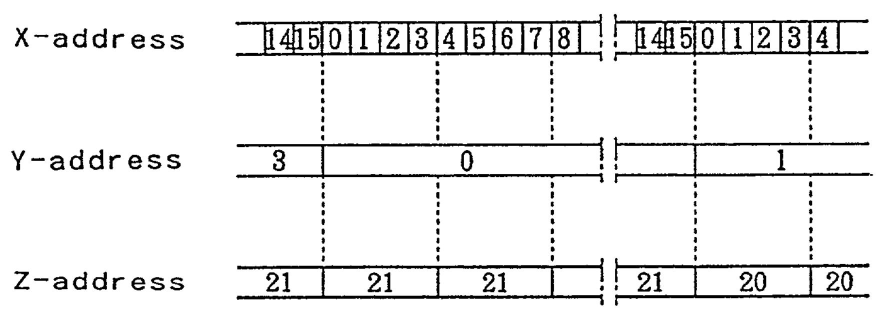

X-address
14 15 0 1 2 3 4 5 6 7 8
14 15 0 1 2 3 4
Y-address
3
0
1
Z-address
21
21
21
21
20
20

Fig. 6

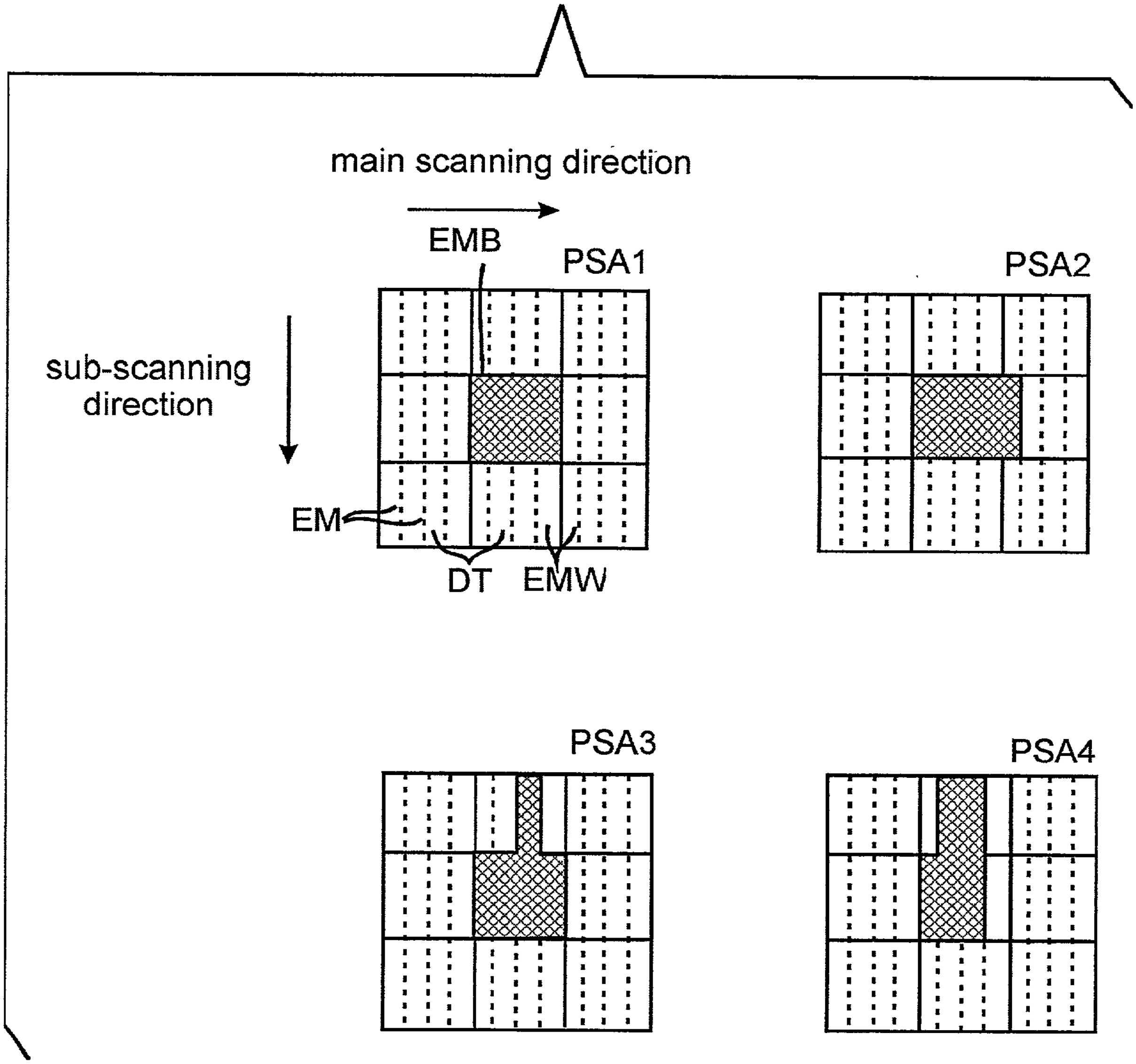
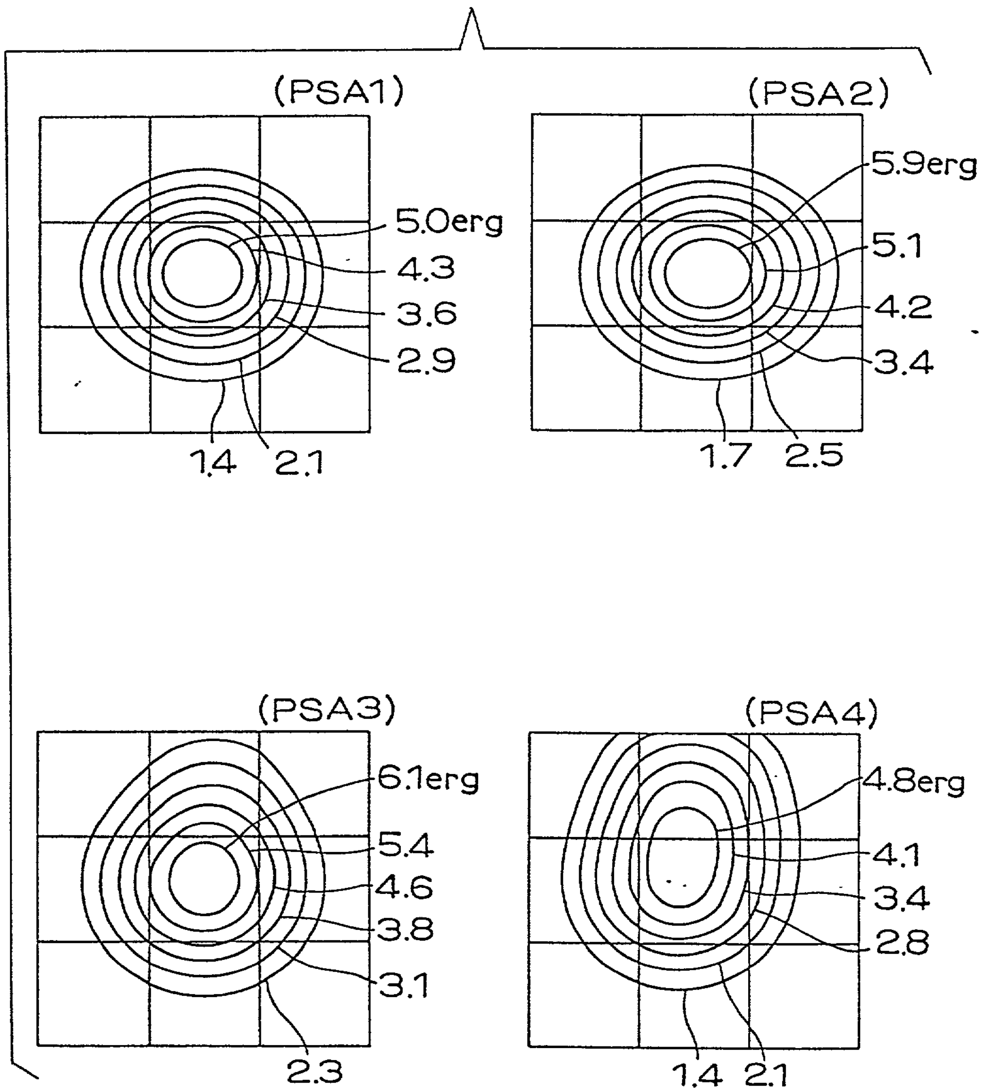

main scanning direction
sub-scanning direction
EMB
PSA1
EM
DT
EMW
PSA2
PSA3
PSA4

Fig. 7



(PSA1)
5.0erg
4.3
3.6
2.9
1.4
2.1
(PSA2)
5.9erg
5.1
4.2
3.4
1.7
2.5
(PSA3)
6.1erg
5.4
4.6
3.8
3.1
2.3
(PSA4)
4.8erg
4.1
3.4
2.8
1.4
2.1

Fig. 8

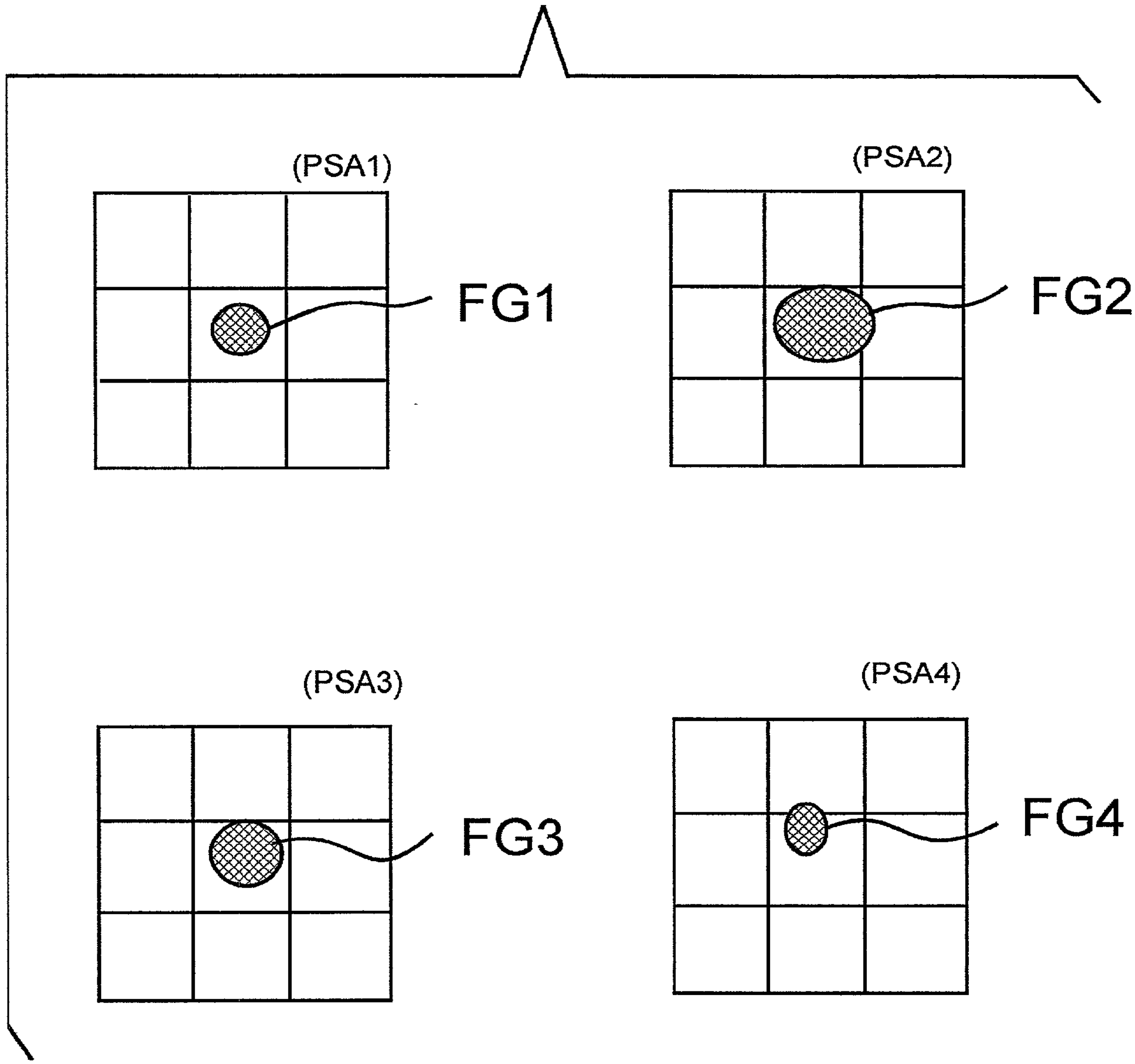


Fig. 9

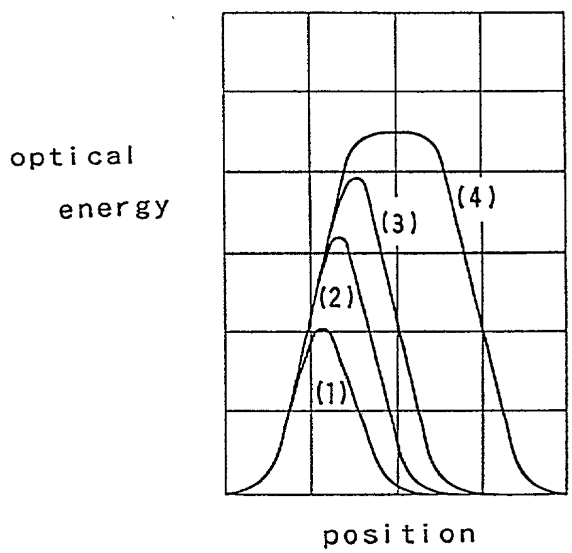
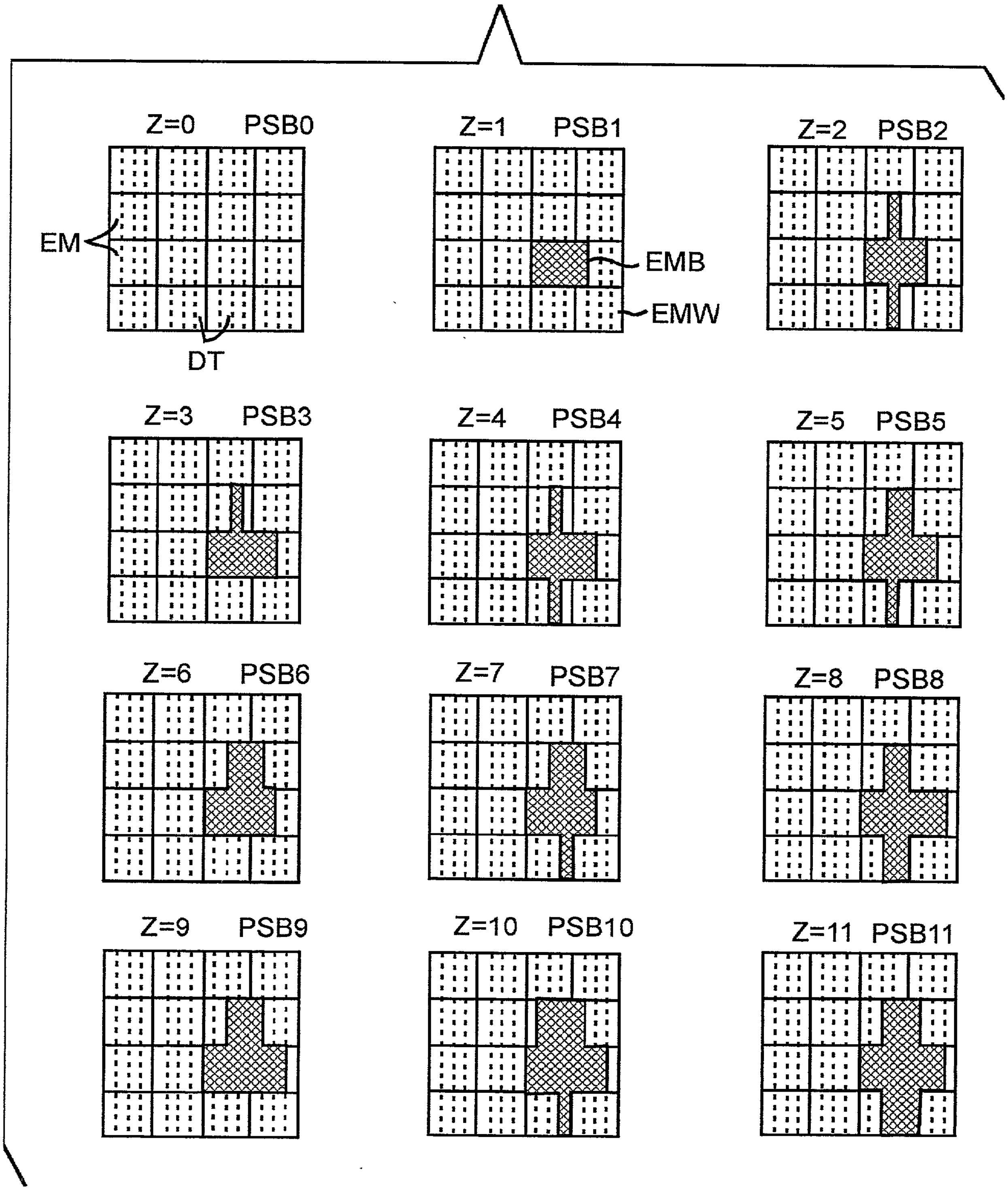


Fig. 10A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PSB0
EM
DT
Z=1
PSB1
EMB
EMW
Z=2
PSB2
Z=3
PSB3
Z=4
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PSB5
Z=6
PSB6
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PSB8
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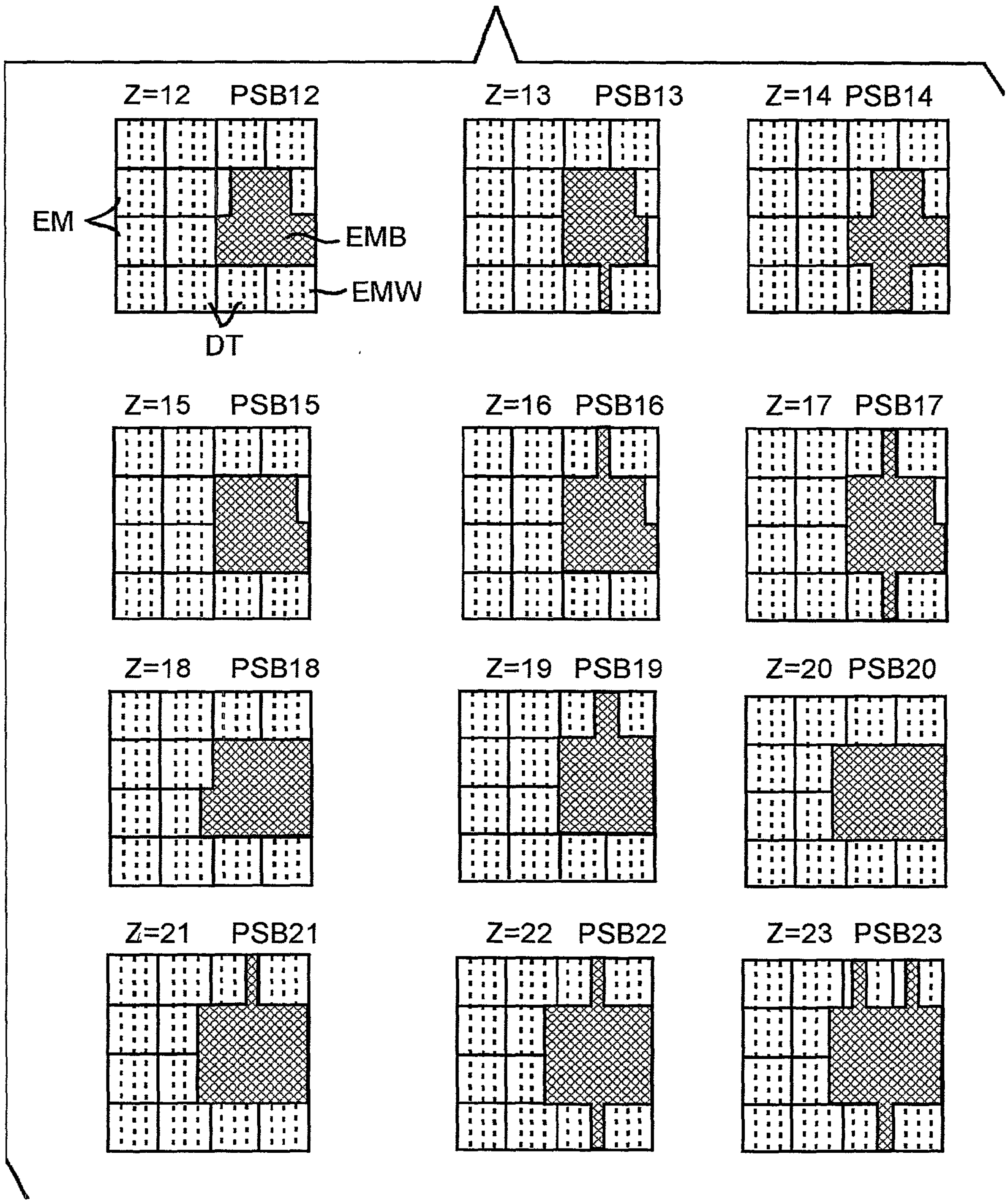
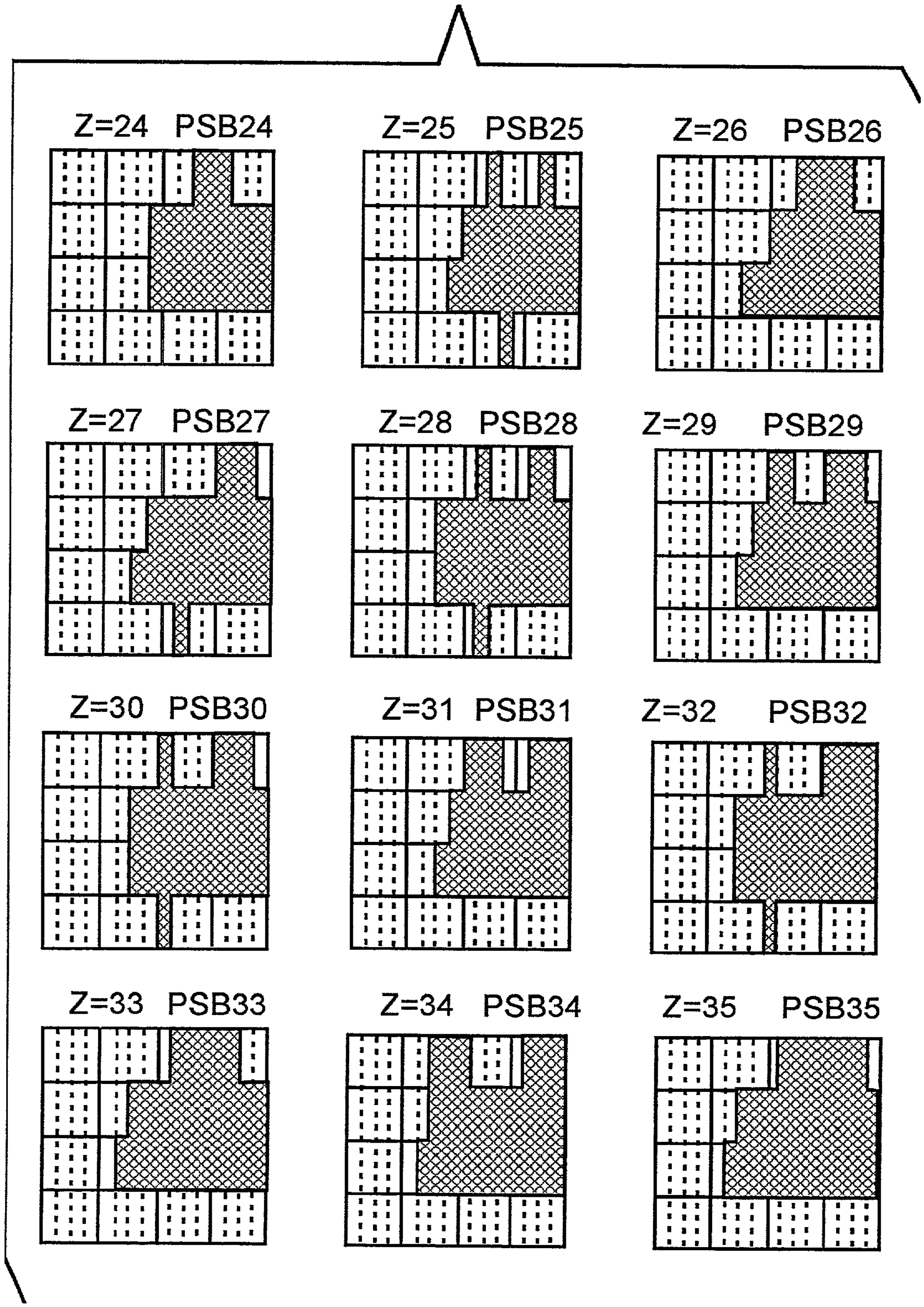
PSB9
Z=10
PSB10
Z=11
PSB11

Fig. 10B



Z=12 PSB12
EM
EMB
EMW
DT
Z=13 PSB13
Z=14 PSB14
Z=15 PSB15
Z=16 PSB16
Z=17 PSB17
Z=18 PSB18
Z=19 PSB19
Z=20 PSB20
Z=21 PSB21
Z=22 PSB22
Z=23 PSB23

Fig. 10C



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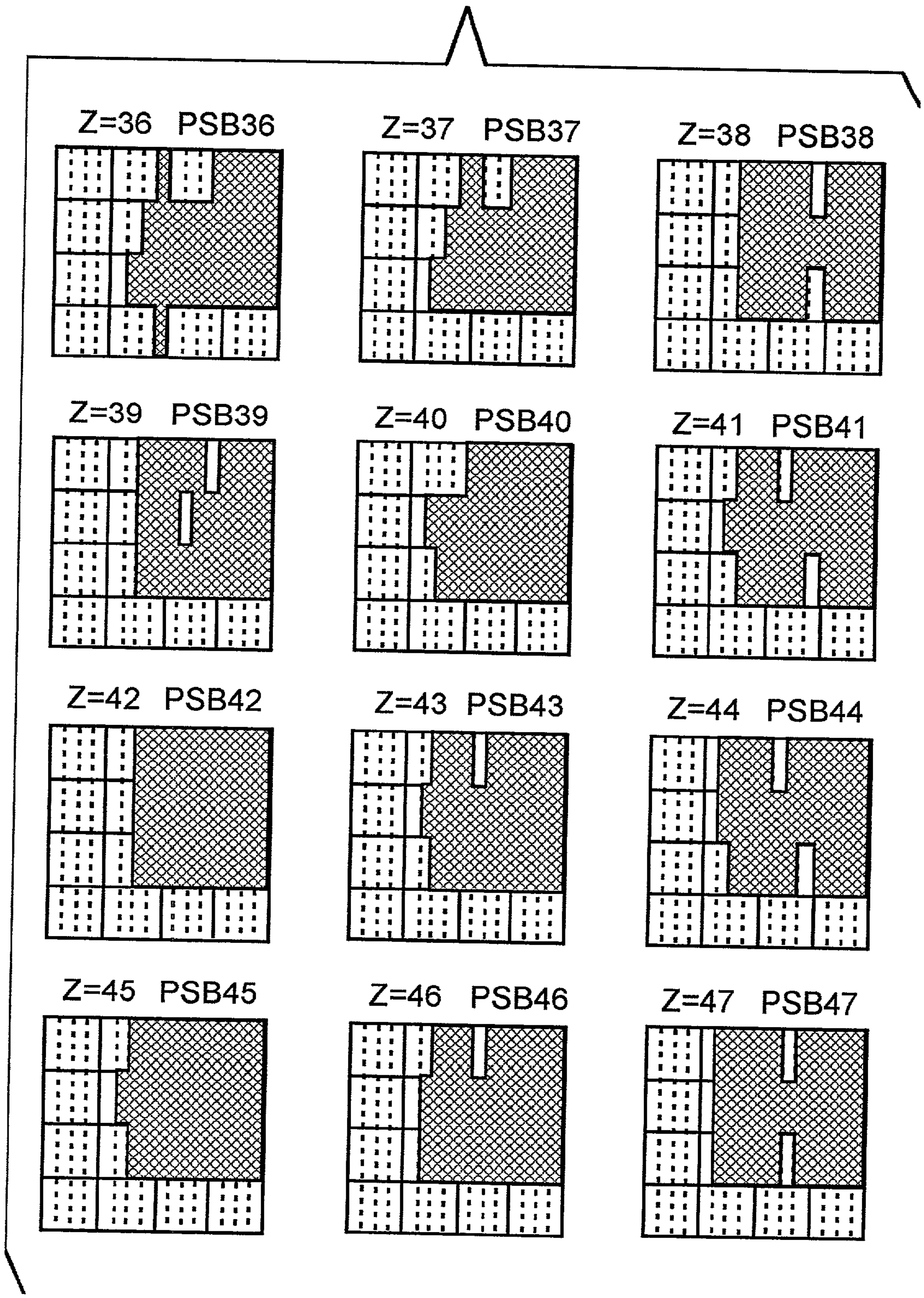
Z=26 PSB26
Z=27 PSB27
Z=28 PSB28
Z=29 PSB29
Z=30 PSB30
Z=31 PSB31
Z=32 PSB32
Z=33 PSB33
Z=34 PSB34
Z=35 PSB35

Fig. 10D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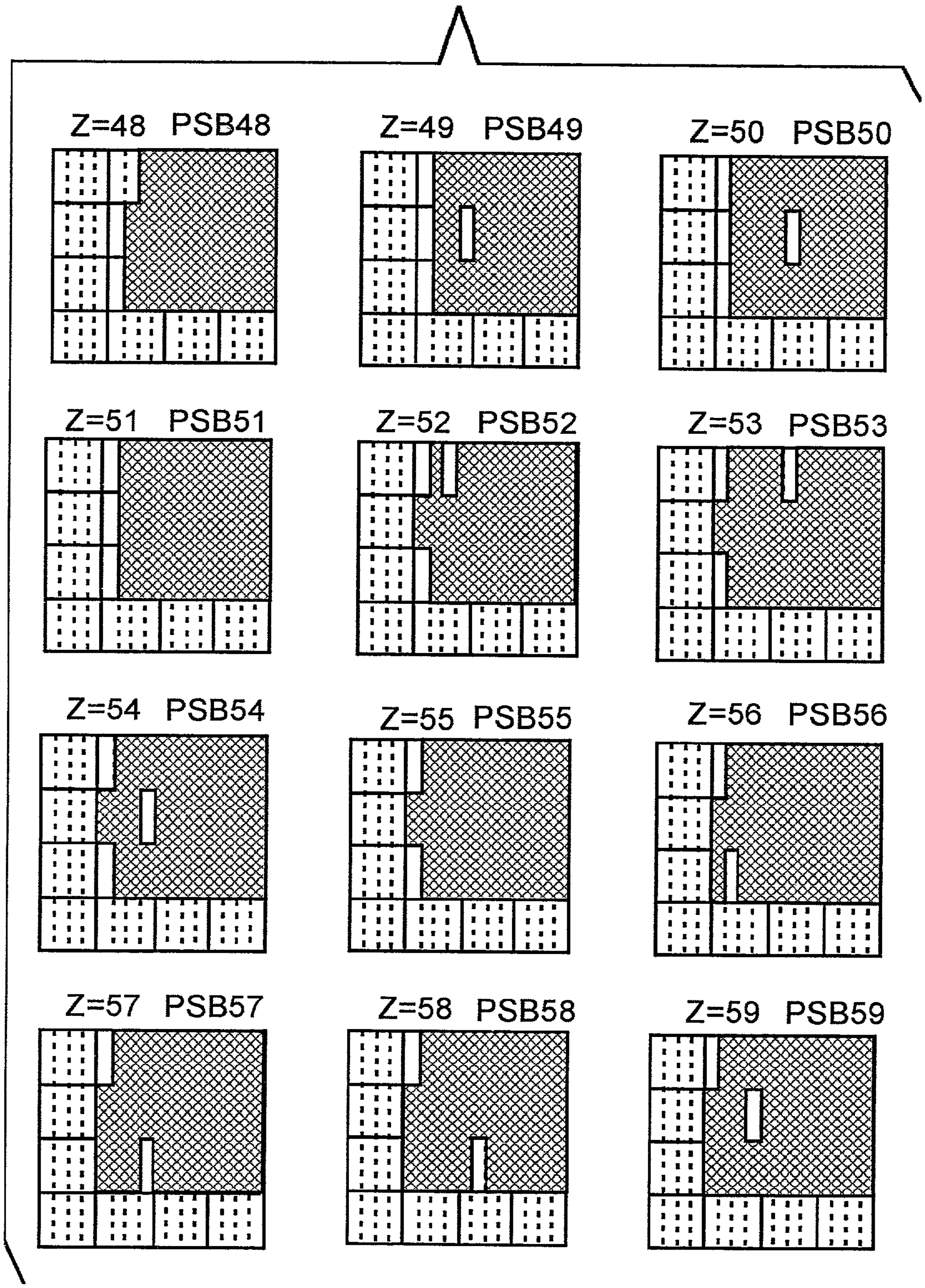
Z=37 PSB37
Z=38 PSB38
Z=39 PSB39
Z=40 PSB40
Z=41 PSB41
Z=42 PSB42
Z=43 PSB43
Z=44 PSB44
Z=45 PSB45
Z=46 PSB46
Z=47 PSB47

Fig. 10E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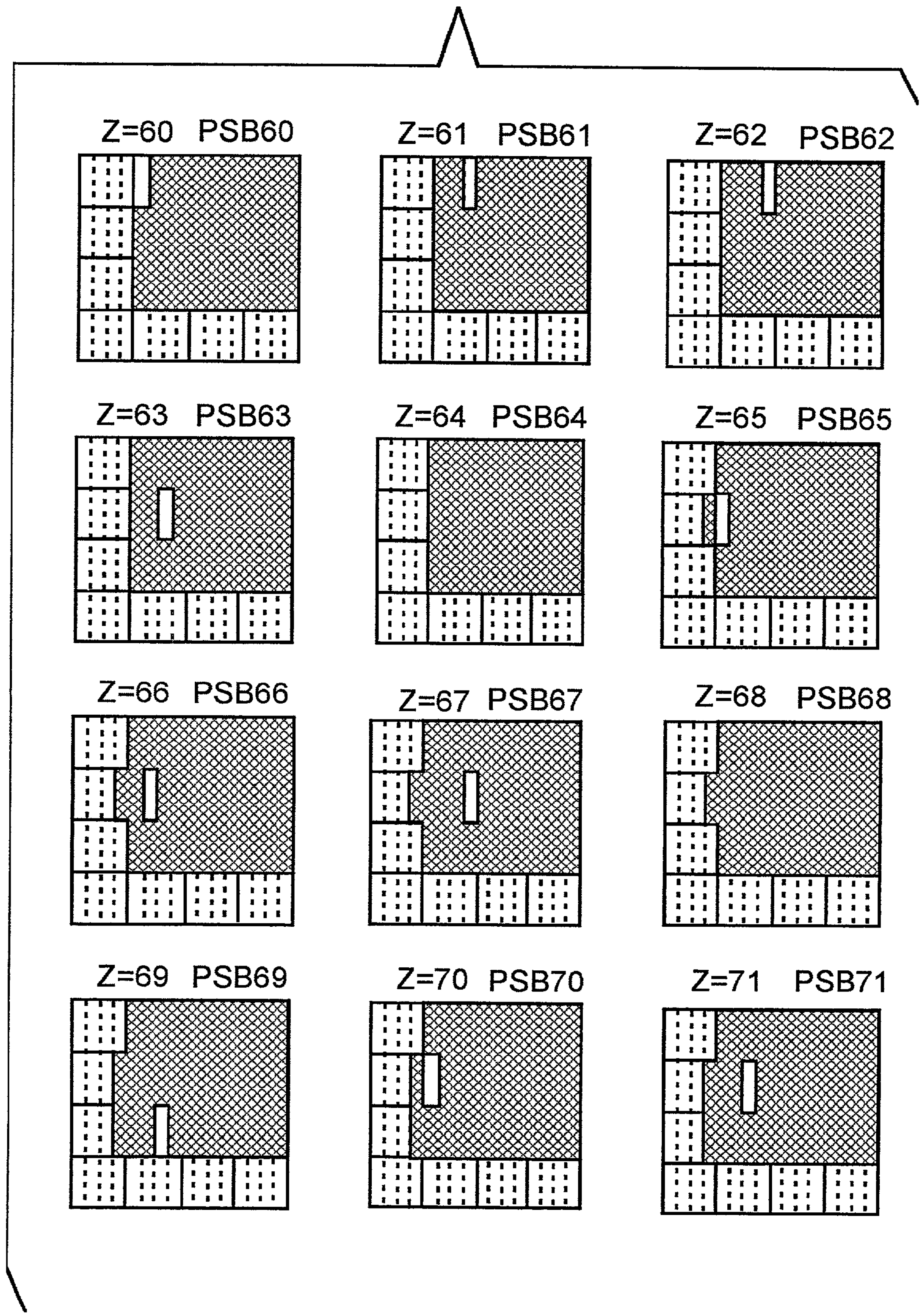
Z=49 PSB49
Z=50 PSB50
Z=51 PSB51
Z=52 PSB52
Z=53 PSB53
Z=54 PSB54
Z=55 PSB55
Z=56 PSB56
Z=57 PSB57
Z=58 PSB58
Z=59 PSB59

Fig. 10F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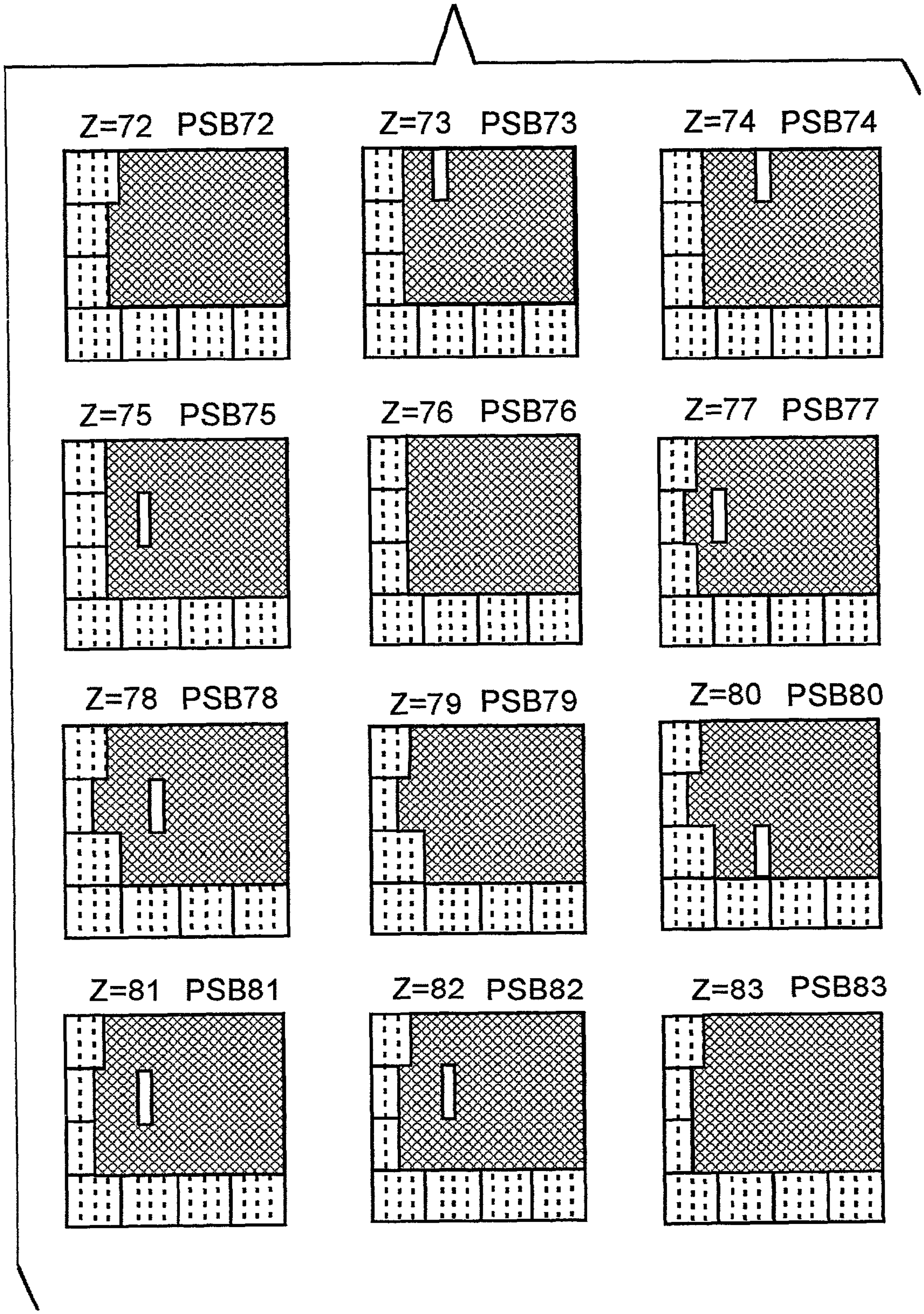
Z=61 PSB61
Z=62 PSB62
Z=63 PSB63
Z=64 PSB64
Z=65 PSB65
Z=66 PSB66
Z=67 PSB67
Z=68 PSB68
Z=69 PSB69
Z=70 PSB70
Z=71 PSB71

Fig. 10G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Z=73 PSB73
Z=74 PSB74
Z=75 PSB75
Z=76 PSB76
Z=77 PSB77
Z=78 PSB78
Z=79 PSB79
Z=80 PSB80
Z=81 PSB81
Z=82 PSB82
Z=83 PSB83

Fig. 10H

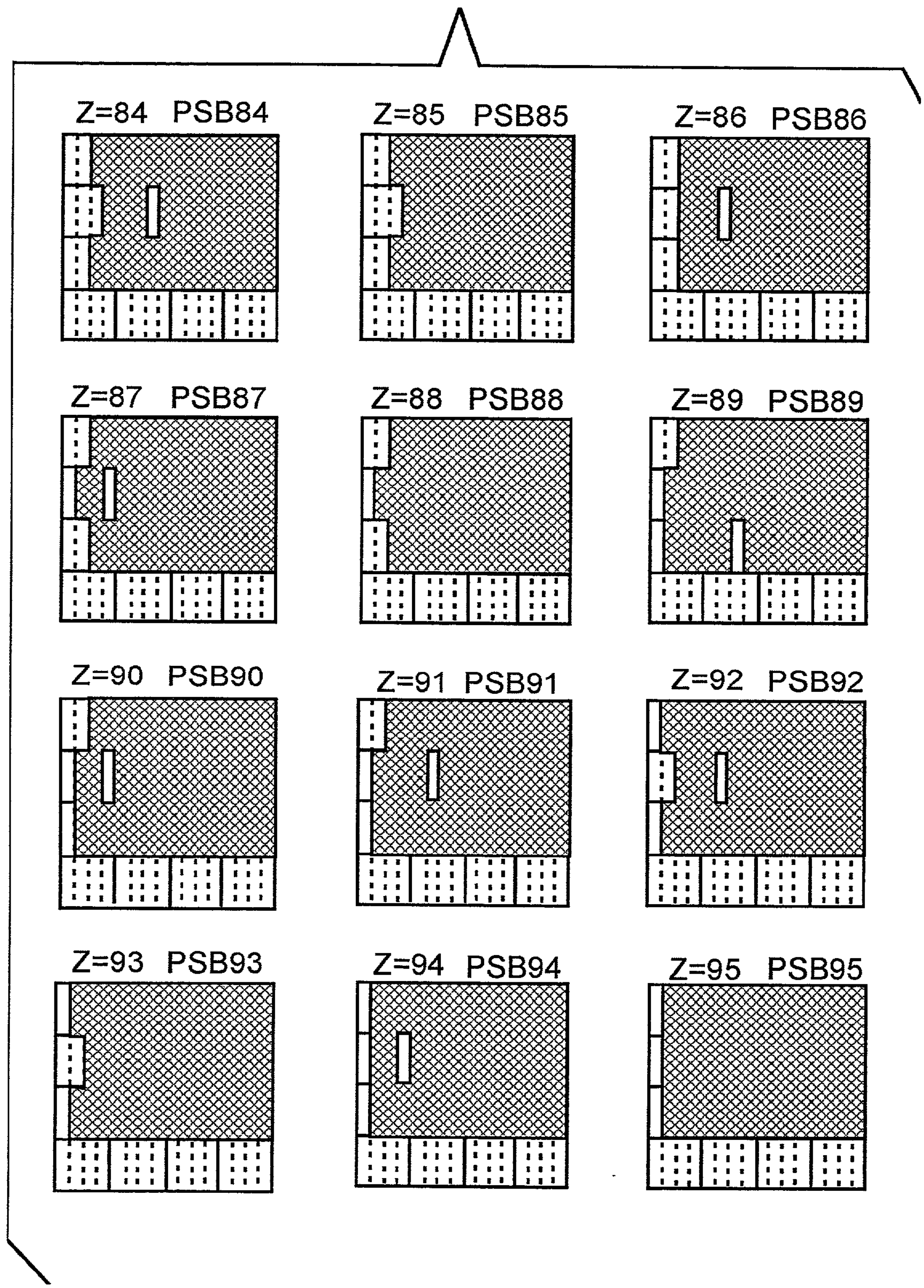
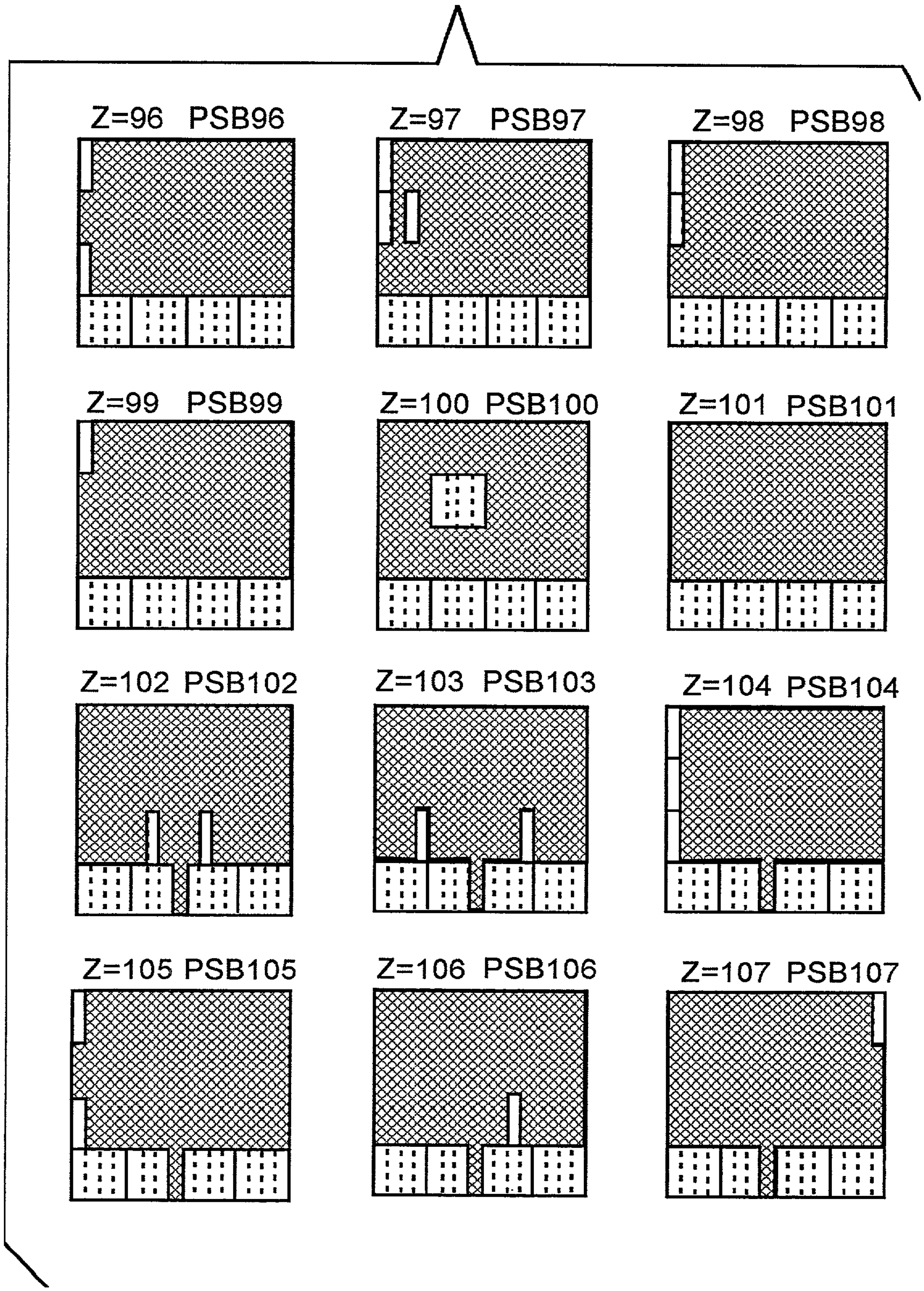

Z=84 PSB84
Z=85 PSB85
Z=86 PSB86
Z=87 PSB87
Z=88 PSB88
Z=89 PSB89
Z=90 PSB90
Z=91 PSB91
Z=92 PSB92
Z=93 PSB93
Z=94 PSB94
Z=95 PSB95

Fig. 10I



Z=96 PSB96
Z=97 PSB97
Z=98 PSB98
Z=99 PSB99
Z=100 PSB100
Z=101 PSB101
Z=102 PSB102
Z=103 PSB103
Z=104 PSB104
Z=105 PSB105
Z=106 PSB106
Z=107 PSB107

Fig. 10J

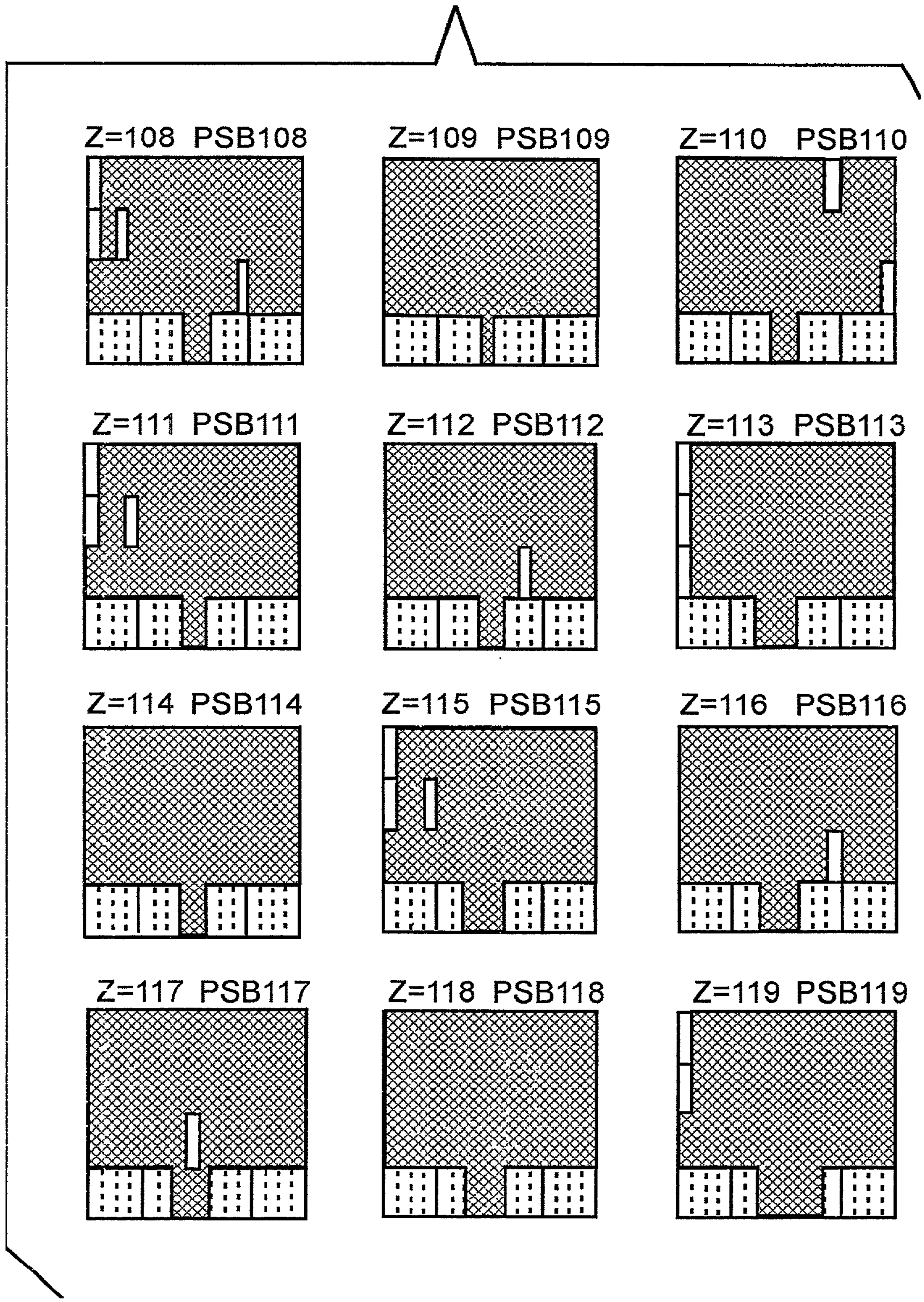
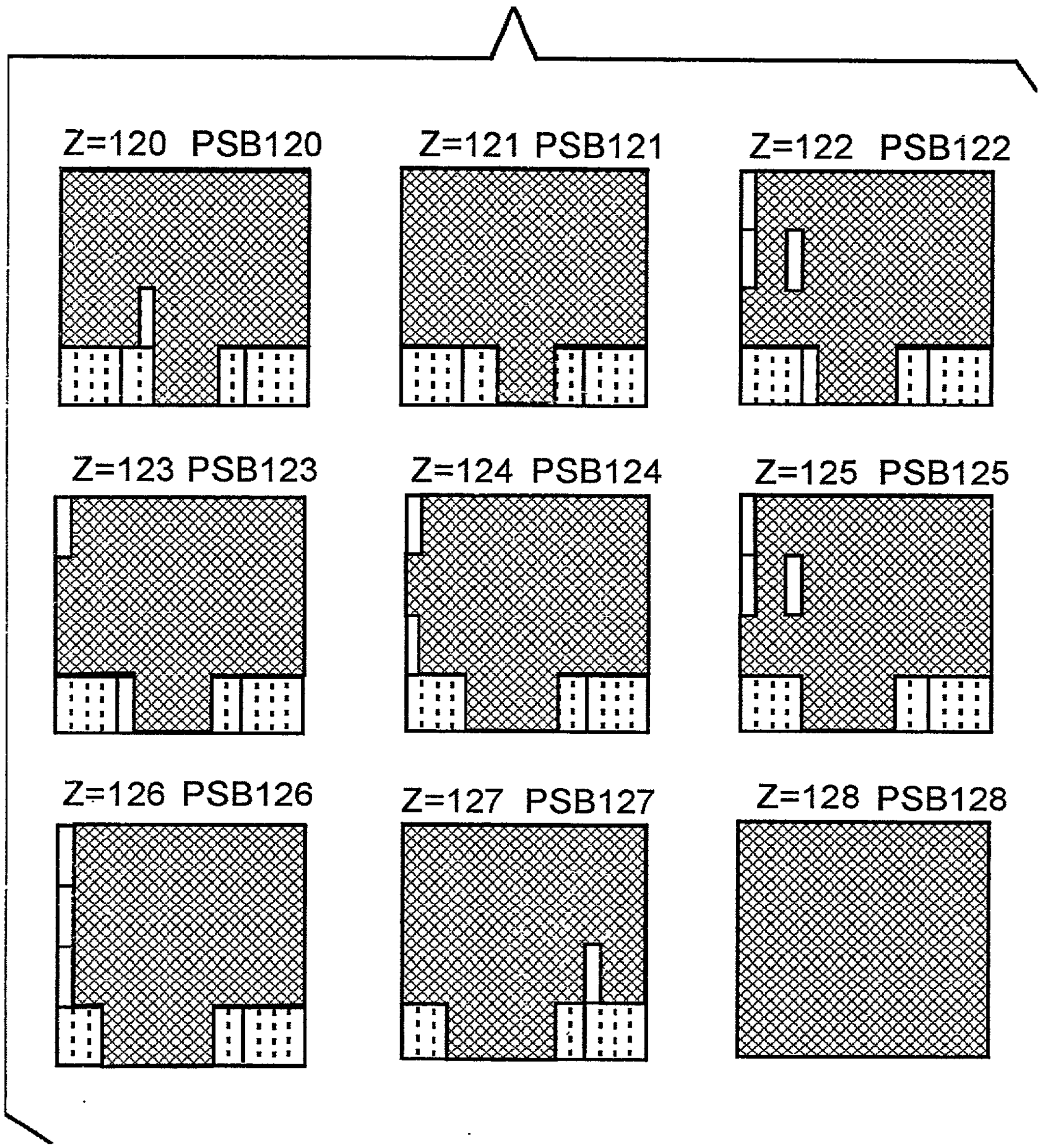

Z=108 PSB108
Z=109 PSB109
Z=110 PSB110
Z=111 PSB111
Z=112 PSB112
Z=113 PSB113
Z=114 PSB114
Z=115 PSB115
Z=116 PSB116
Z=117 PSB117
Z=118 PSB118
Z=119 PSB119

Fig. 10K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Z=122 PSB122
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Z=126 PSB126
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Z=128 PSB128

Fig. 11

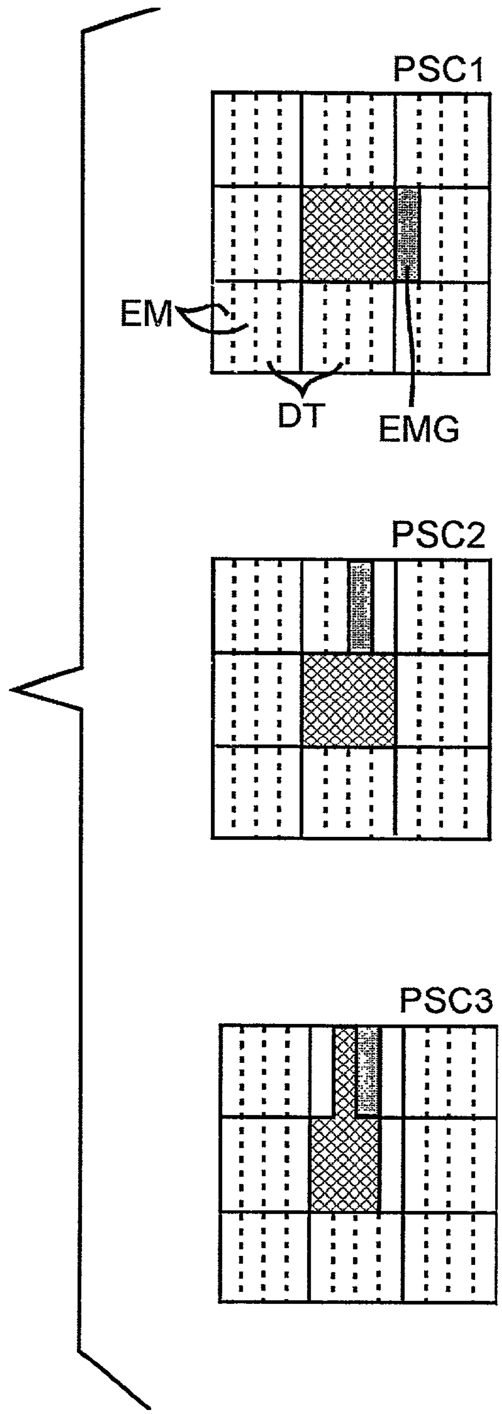


Fig. 12

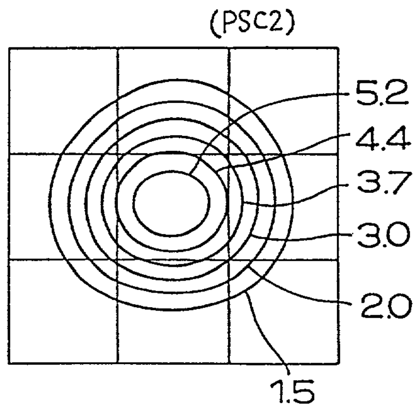
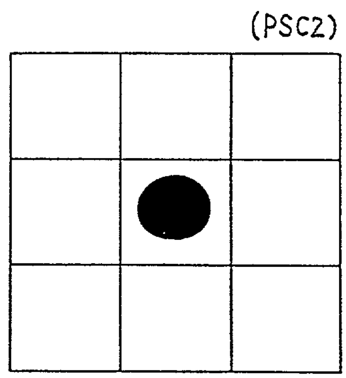


Fig. 13



Patent
Attorney's Docket No. 018655-773

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of Hiroshi GOTO et al. Patent No. 5,790,272 Application No.: Unassigned Filed: October 17, 1994 For: MULTI-TONE IMAGE PROCESSING METHOD AND APPARATUS	Group Art Unit: 2111 Examiner: D. Jardieu

DECLARATION UNDER 37 C.F.R. § 1.175

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

We, Hiroshi Goto and Satoshi Deishi, hereby declare as follows:

(1) We are citizens of Japan, having a post office address of c/o Minolta Co., Ltd.; Osaka Kokusai Bldg., 3-13; 2-Chome, Azuchi-Machi, Chuo-ku, Osaka-shi, Osaka, Japan.

(2) We believe that we are the original, first inventors of the invention described and claimed in the United States Patent No. 5,790,272 and in the specification and the claims of the Reissue Application filed herewith.

(3) We have reviewed and understand the contents of the specification and the claims of the Reissue Application.

(4) We hereby claim the benefit of foreign priority under 35 U.S.C. § 119 with respect to Japanese Patent Application No. 5-259691, filed on October 18, 1993.

(5) We acknowledge the duty to disclose information that we are aware of which is material to the examination of this Reissue Application in accordance with 37 C.F.R. § 1.56(a).

(6) We believe the original patent to be partly inoperative or invalid by reason of the patentee claiming more or less than the patentee had the right to claim in the patent. Specifically, Applicants failed to include the subject matter of claims 29-36 which are included in this reissue application. In addition, claim 24 includes an error at line 10 of the printed patent, wherein the term "lighter" should have been "darker". And, claims 1-16 and 25-28 are canceled.

(7) All errors which are being corrected in this reissue application up to the time of filing of the declaration arose without any deceptive intent on the part of the Applicants.

(8) The undersigned declare further that all statements made herein are of our own knowledge and are true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title of the United States Code and that such willful false statements may

Application No. Unassigned
Attorney's Docket No. 018655-773

jeopardize the validity of the application or any patent issued thereon.

Respectfully submitted,

By: Hiroshi Goto
Hiroshi Goto

Date: Mar. 29, 1999

By: Satoshi Deishi
Satoshi Deishi

Date: Mar. 29, 1999

Patent
Attorney's Docket No. 018655-773

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of	
Hiroshi GOTO et al.	Group Art Unit: 2111
U.S. Patent No. 5,790,272	
Application No.: Unassigned	Examiner: D. Jardieu
Filed: October 17, 1994	
For: MULTI-TONE IMAGE PROCESSING METHOD AND APPARATUS	

OFFER TO SURRENDER U.S. PATENT NO. 5,790,272

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Minolta Co. Ltd. is the assignee of the entire interest in U.S. Patent No. 5,790,272, and hereby offers to surrender U.S. Patent No. 5,790,272. A certificate under 37 C.F.R. § 3.73(b) is attached.

I am authorized to act on behalf of the assignee.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the likes so made are punishable by a fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity

Application No. Unassigned
Attorney's Docket No. 018655-773

of the application, any patent issued thereon, or any patent to which this declaration is directed.

Minolta Co., Ltd.

By: O. Kanaya.
Mr. Osamu KANAYA
President
Minolta Co., Ltd.

Date: Mar. 25. 1999.